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- Revealed: the big omission

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Full contents overleaf

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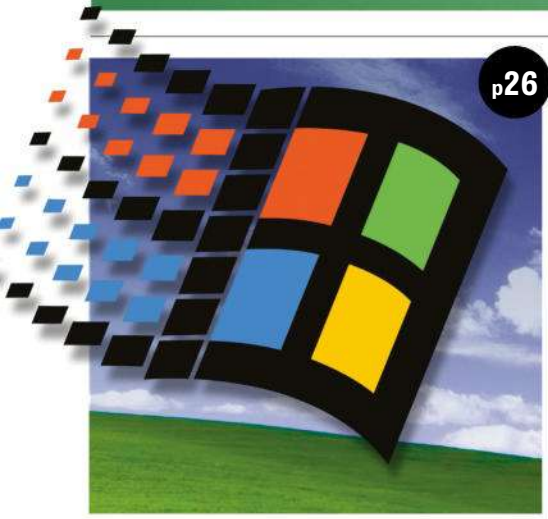
REVIEW OF THE MONTH

Scan 3XS Evolve Studio Pro

There are two ways of looking at this £5,000 system. First, as a complete waste of money: who the heck needs an RTX 5090 graphics card and AMD Ryzen 9 9950X3D processor? Especially when you can buy PCs such as the PCSpecialist Eclipse R70I Lumin (*see p57*) for less than half the price. But here's a second point of view: you're investing money in a computer that will excel into the 2030s. You're also buying a PC that will look the part thanks to its stylish chassis, to the point where you may choose to simply upgrade the internals rather than the entire machine. Make up your own mind from p48.



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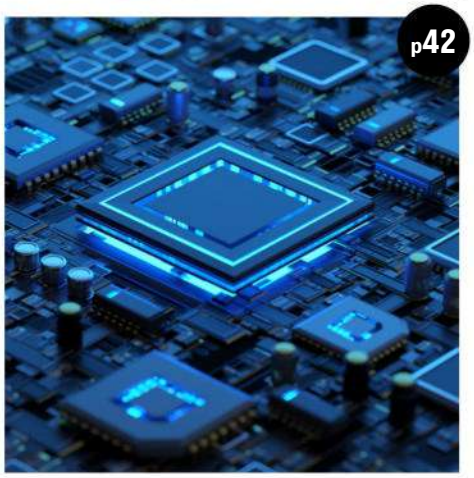

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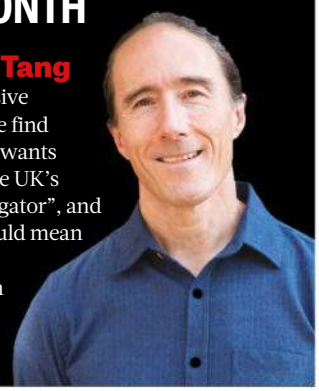

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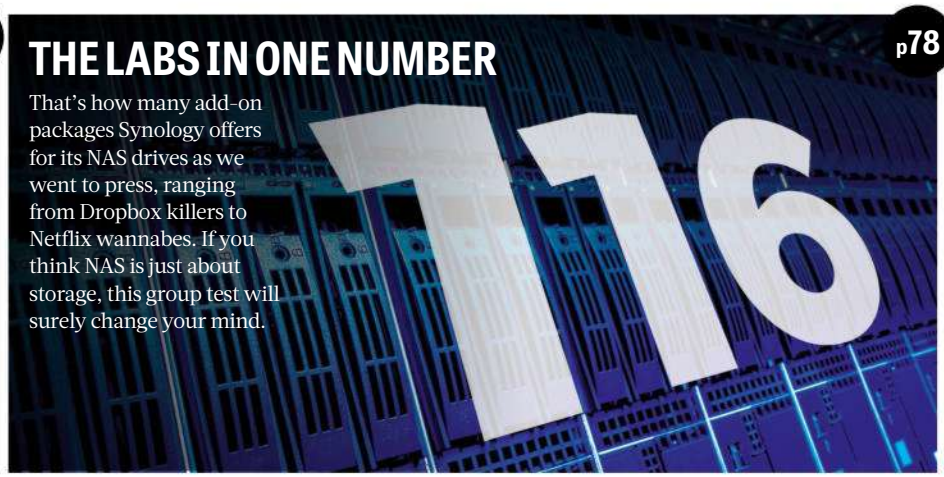

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Eizo's 4-watt monitor: no power supply required

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Never mind Windows 95, let's time travel back to 1950

Flmmff. That, I need hardly tell you, is the sound of a wormhole appearing in the space-time continuum, through which I've just sent three gentlemen a copy of this magazine. In their world, it's 1950. One falls into the lap of Maurice Wilkes; another lands next to FC Williams; and the third flies into Alan Turing's pigeonhole at King's College, Cambridge, which I know he'll be checking in a couple of minutes.

Of those three names, you'll surely be most familiar with Turing. You may also have a passing knowledge of Maurice Wilkes, but you probably won't have heard of FC Williams. I only know about these latter two because I've spent the past year researching and writing a book called *The Computers that Made the World* (on sale this summer, thanks for asking). Had this magazine been around 75 years ago, however, they would all have featured prominently as British computing pioneers of world repute. And once they've overcome their excitement at receiving this month's copy of *PC Pro*, I hope they recognise it as a thank you.

What can we thank them for? Well, in 1948 FC Williams was responsible for creating the Manchester Baby, the world's first stored-program computer. His breakthrough in data storage using cathode ray tubes would shortly be exported to IBM in America, advancing the computing industry without a sniff of a tariff (*see p10*). A year later in Cambridge, Wilkes' EDSAC computer ticked into life, a Big Bang moment for computing that has repercussions to this day.

And all of this was arguably kicked off by Alan Turing's 1936 paper, "On Computable Numbers", which introduced the idea of a Universal Turing Machine – an idea Turing sought to realise in the ACE project, but which finally materialised, in humbler "Pilot" form, in 1950.

Three quarters of a century later, these legacies all live on in this month's magazine. For FC, proud of his northern roots, we have a three-page review of Bolton-based Scan's 3XS Evolve Pro on p48. Don't be shocked, FC, but this computer doesn't fill a room and costs a mere £5,000. A bargain compared to the millions of pounds paid for the Baby's successor, the Ferranti Mark 1.

Maurice's legacy endures in every phone and tablet in our Reviews section, along with the new Mac Studio (*see p52*). He can claim much of the credit for the University of Cambridge becoming a centre of excellence in computing, where graduates Steve Furber and Sophie Wilson created the Arm architecture that powers them all.

And for Alan, I humbly present a three-page article on the future of weather prediction (*see p126*). He, arguably more than anyone, foresaw the use of computers in such organic things, and the report happens to be based on an event at the Alan Turing Institute – a fitting tribute.

If you'll allow me one last historic flourish, we're about to hit the 30th anniversary of the launch of Windows 95. Turn to p26 for our inside story on the launch of Microsoft's epochal operating system to find out what went right – and occasionally wrong.

Tim Danton
Editor-in-chief

PC Pro needs your help!

Who will win this year's *PC Pro* Excellence Awards? Only you can tell us, so please complete our survey so we can find out!

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Microsoft is now 50 years old. Out of all that time, what do you think was its most important release (or contribution to technology as a whole)?

"I'm going to head all the way back to MS-DOS, which powered the first IBM PC back in 1981. Without this, Microsoft may well have remained as a software and add-on supplier for Apple and fizzled out, along with Apple, in the mid-1990s."

"Embarrassed to say for me it's Word. Hated it at first, grumbled about the ribbon, switched to Libre and then Google Docs, but its fundamental ops are hard-wired in my brain (apart from Ctrl-C, Ctrl-X and Ctrl-V, which remain from WordStar)."

"Arguably Windows 95 – it certainly had its flaws, but it was perfectly positioned and timed to kickstart the era of the true mass-market productivity PC."

"In terms of saving the company, probably Azure. Without that cloud push, I don't think Microsoft would be anything like the force it remains today."

"Excel 1.0 on the Macintosh. It was an absolute quantum leap in thinking and expressing maths stuff."

"Windows XP marked a shift to a true operating system, moving away from its DOS-based predecessors. Its advancements in multimedia, internet connectivity and gaming made it a household favourite."

"Windows NT. Proper foundational OS comes to the PC world in a way that makes sense to normal users."

"The Steve Ballmer bot. Especially the one with the David Brent dance upgrade."

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Briefing

Background and analysis on all the important news stories

China and Taiwan have been hit with huge tariffs for goods imported to the US

Trump tariffs are "like Covid again" for PC firms

Huge uncertainty over supply chains will disrupt PC prices and stocks this year

When it comes to Donald Trump, absolutely nothing is certain. But it's that very uncertainty over the impact and longevity of the president's damaging tariffs policy that is causing concern for PC manufacturers.

"It's almost like when Covid first came in," said a spokesperson for UK-based PC manufacturer Wired2Fire, just days after Trump announced his sweeping set of global tariffs. "Do we prepare for disaster recovery or do we try and hire extra staff for extra demand? Nobody had a crystal ball and we didn't know [how Covid would pan out], and it ended up being [a] huge demand surge in IT. But quite frankly, we were preparing for the worst case. It feels like that all over again."

International trade negotiation is normally a process conducted over a period of years, with transition periods to allow everyone to adjust. Donald Trump announced a sweeping set of global tariffs in front of the White House only three days before the first set of tariffs came into effect. The world was given more notice – much more notice – of a global pandemic than Trump's all-encompassing tariffs.

When we spoke to a number of PC manufacturers in the days after the tariffs were announced, they were every bit as stunned and uncertain as global stock markets, which crashed on a scale not seen since the early days of the pandemic in 2020. Many declined to speak on the record, either because they were simply still trying to calibrate the impact on their business or through fear of saying something that might trigger a volatile president (we're not sure if the White House has cancelled its *PC Pro* subscription yet).

However, with manufacturing hotspots such as China and Taiwan

among those hardest hit by the tariffs, there's no doubt that they've had an immediate and damaging effect. Components such as memory and SSDs are sold almost like commodities, with prices that fluctuate on a daily basis. "They don't respond well to uncertainty, and that normally drives prices up quite aggressively, because people would rather have stock than not," said the spokesperson for Wired2Fire.

"That drives up demand in the short term. And as soon as you get a demand spike, it starts to go up in cost, so it wouldn't surprise me if DRAM and SSDs suddenly start to spike in price, just because it responds like stocks and shares to this kind of uncertainty."

On the day after we spoke to the Wired2Fire spokesperson, we were indeed seeing the quoted prices of components start to rise for PC builders. SSD prices had climbed by up to 10-15% and were still rising, according to off-the-record conversations we had with PC component suppliers, because demand had suddenly risen and NAND production in China and Taiwan has been low this year. The weakening dollar was also pushing up prices.

The suppliers we spoke to had also witnessed a surge in system builds in the first quarter of 2025 because of the looming Windows 10 support deadline. With prices rising, transitioning to Windows 11 could suddenly become a much more expensive upgrade than anticipated for both consumers and businesses. And that 14 October deadline is edging ever closer.

Diverting stocks

Another uncertainty in the PC market is what happens to stocks that were once destined for the US, but now won't be sold because of tariffs either making supply unprofitable or unaffordable for US consumers.

Although a relatively small player, Framework announced that some of its lower-end laptops would no longer be sold in the US as a direct consequence of the tariffs. "We priced our laptops when tariffs on imports from Taiwan were 0%," the company said in a post on X. "At a 10% tariff, we would have to sell the lowest-end SKUs [stock-keeping units] at a loss. Other consumer goods makers have performed the same calculations and taken the same actions, though most have not been open about it."

It's not only smaller players that have been disrupted by the turmoil, though. Just days after it announced the Switch 2 console, Nintendo said it was pausing pre-orders of the next-generation handheld console in the US while it tried to work through the implications of the tariffs. The head of Nintendo of America told The Verge that the price of the console was set before Trump's announcement and the tariffs would be "something we're going to have to address".

"A lot of the companies that I'm friendly with in Asia have just said that they're going to pivot their business targets away from the States," said the spokesperson for Wired2Fire. He cited the example of a PC case manufacturer that might previously have sold units for $20, but would now have to push that price up to at least $30 as a consequence of the tariffs. "That's going to be up to a third increase straight off the bat for American customers, and they probably won't have an appetite to pay that surplus," he said.

That could lead to a glut of inventory arriving in alternative markets such as the UK and the European Union, potentially bringing prices back down.

There are other potential upsides for British exporters, too, given the UK has (at the time of writing) been placed in one of the lower tariff bands. "It could potentially open up an opportunity whereby if we can get goods into America at a 10% tariff, and China and Taiwan are getting them in at 36+ percent, suddenly we can be competitive on finished goods," said the Wired2Fire spokesperson.

> "It wouldn't surprise me if DRAM and SSDs suddenly start to spike in price, just because it responds like stocks and shares to this kind of uncertainty"

That, however, depends on how strictly the tariffs are applied. Will the US simply look at the origin of the finished goods, or will it apply a levy based on the origin of the components inside a PC? "If they're not going to look at the actual origin of components, then everyone's just going to set up a shell company and just have it imported in via a low-cost country," said the Wired2Fire spokesperson.

Such big decisions require certainty over how the tariffs will be applied. At the time of writing, around the time the most draconian "reciprocal" tariffs are being implemented, none of that was certain. It's a state that we're going to have to get used to. Probably.

Microsoft heads off CrowdStrike 2

Quick Machine Recovery to avert Windows boot disasters

Better late than never, Microsoft is implementing a new Windows feature that should prevent a repeat of incidents such as last year's CrowdStrike calamity. Called Quick Machine Recovery, the new system should allow both IT professionals and Microsoft to recover machines that are trapped in failed boot loops.

CrowdStrike caused widespread chaos in July 2024 when a flawed kernel-level update of the company's Falcon software caused millions of Windows PCs to crash and fail to reboot. Initially, machines were only recoverable locally, meaning it took several days for some businesses to recover. The incident affected airlines, banks, hospitals and many other businesses across the world.

Quick Machine Recovery was first announced last year, as part of Microsoft's Windows Resiliency Initiative. Now the feature is being tested with Windows Insiders.

The new feature will see a machine that has repeatedly failed to boot properly enter a recovery environment. Once it reaches that recovery stage, the machine will establish a network connection (either via Ethernet or Wi-Fi) and send diagnostic data to Microsoft. The company can then use this data to identify widespread outages and (hopefully) deploy a solution that is distributed via Windows Update. After the remediation is applied, the device boots back into Windows as normal.

IT admins will be able to enable or disable Quick Machine Recovery, as well as preconfigure the network credentials the machine should use during recovery, and set how long a machine should wait after a failed recovery before trying to run the recovery process again.

It's not only businesses that will benefit. Windows 11 Home users will have cloud remediation turned on by default, according to Microsoft's support page, which is also keen to play down the idea of this being a silver bullet for every blue-screen scenario. "Quick Machine Recovery is a best-effort feature," Microsoft states. "It might not always be able to find a solution for every issue."

Quick Machine Recovery is currently being tested

Britain's full-fibre alternative

Richard Tang, Zen

Zen Internet CEO Richard Tang wants to bring Britain's disparate fibre networks together

Britain's full-fibre networks have become a patchwork quilt of more than 100 different providers. Zen Internet boss Richard Tang wants to do something about that.

As an ISP, striking wholesale deals with different fibre providers is a pain. Different contracts, different pricing, different APIs. So Tang wants Zen to become an "altnet aggregator", connecting to several different altnets and then allowing channel partners or even rival ISPs access to all those different networks via Zen. One contract, one API, much less hassle.

The curious thing is that even Tang believes that the vast majority of these altnets won't be around in as little as five years' time. A predicted wave of consolidation will see the full-fibre market dwindle down to only a handful of different networks, Tang predicts. So why does he want to become their champion? We sat down with the Zen boss to find out.

PC Pro: Tell us more about your plans to become the altnet aggregator.

Richard Tang: This is something that's been in the thinking for about a year, 18 months. We signed the [wholesale broadband] deal with CityFibre back in 2022, that's going really well, but we'd not thought much of going beyond CityFibre. And then 12-18 months ago we were thinking the other altnets are making good progress. Is there an opportunity?

If you look at Zen today, we supply 215,000 broadband lines out of a UK total of something like 28-29 million. So that means we've got 0.7% of UK market share.

Let's say we could expect 1% or 2% market share on CityFibre [because there's less competition – no BT Broadband, for instance]. Well, that means with 4 million circuits, we could expect maybe 40,000 circuits, up to 80,000 circuits on the current footprint. That's a lot of circuits. That's really worthwhile.

> "If we can offer a single connection, then that puts us in a pretty unique position"

Talking to a lot of the altnets, you could see that they hadn't reached a scale where they're so big that you've got to interconnect with them. And they were desperate to get customers on their network. And that's where this idea of an aggregator came from. I thought what's needed here is someone to aggregate all the altnets.

If we can offer a single connection into five, six, seven, eight different altnets, then that puts us in a pretty unique position in the UK, both for our direct sales and for our channel sales.

PC Pro: When we spoke a year ago, you said there was only space in the market for two or three different altnets. So are you looking at this as a short-term proposition?

Richard Tang: I'd say medium term. It's a window of opportunity between now and towards the end of the decade.

Most people acknowledge that we will get the consolidation as we did in the 1990s with the cable companies, and there'll be one or two big entities at the end, and there may be some niche rural players as well.

Let's say we get to 2030 and the whole altnet aggregation play from Zen has disappeared because there's only one or two altnet entities in the UK, that's four or five years where we've made really good business, grown our customer base and the growth in the customer base will persist long term.

PC Pro: There's a risk that some of the altnets collapse. Is part of what you're doing building those relationships so that it leaves you well placed to potentially pick up those altnets' retail customers?

Richard Tang: Yeah, we see that as a real opportunity. We weren't successful in a bid for Lit Fibre [which was

RIGHT Zen Internet currently supplies 215,000 broadband lines out of a UK total of around 29 million

LEFT **Consolidation in the full-fibre market could benefit consumers**

acquired by CityFibre in 2024, but sold off its retail ISP business], but I am expecting that in the near future we'll announce a couple of acquisitions. Once we've demonstrated to the market that we're in the market to buy, and we've done a couple and it's worked well, then I think that will be a good opportunity for us.

PC Pro: From a retail perspective, you're currently in a situation where you publish one set of tariffs if the customer is on the Openreach network, and another set if the customer is on CityFibre. If you're going to end up with five or six different altnets in your aggregator, does that means five or six different price schemes for customers?

Richard Tang: No, we'll end up with an Openreach price and an altnet price.

The approach that is uniform across all the altnets is "we're competing with Openreach, we need to be cheaper", and the number I've typically heard is we need to be 20% cheaper than Openreach. So there's no justification for us to complicate things by having five or six different prices.

That leads on to the question... can they do that long term, or is it the case that they're selling at a loss just to build market share? My own feeling is there's definitely some of that going on, which is good news for consumers, because it means they're getting a gigabit full-fibre service for less than it's costing the supplier to provide it. That's good news, but it does mean that there has to be a time when that price hikes. But when it does, it's probably not going to be unreasonable.

PC Pro: So you think it's more likely the altnet prices will go up rather than Openreach having to reduce its prices to compete?

Richard Tang: I think we'll probably see a little bit of both. One thing I'm really, really liking at the current time in the industry is the amount of free market competition. It's the healthiest that I've seen in 30 years of being in this game.

If I look back on most of the last 30 years, BT has had an advantage because they were the monopoly, and they've benefited massively from that advantage. But [now] you can see them respond to the competitive threat. And I think that's been really good. It's been really good for Openreach to have sharpened their pencil. They've been more ambitious, they've been more innovative.

It's great for consumers because they've got choice. Some of our consumers, they've got a choice of two or three different full-fibre providers, and that's brilliant.

PC Pro: Finally, you recently changed your company mission statement to "do right for people and planet". What does that actually mean in practical terms?

Richard Tang: So, we've got this new purpose statement... but actually the purpose of Zen has been that for years and years. And I came up with this new idea, "do right for people and planet", and we [the employees] voted, and that won by a majority, so we changed it.

> "I'm trying to create a model for a new version of capitalism"

But to the question of what can we do in practice? First of all, we can set the culture within Zen, which is all about doing our best as a company, for people, for the environment. So, it's looking at energy supply, putting solar panels on the roof, switching to a 100% biogas tariff – which is more expensive but more environmentally friendly – looking at working with our supply chain, and particularly with Openreach to understand the carbon footprint and come up with an industry-wide path to net zero.

My vision for Zen is it's a company that, as the strap line says, does right for people and planet. The reason that we exist as a business is to contribute as best we can to both the climate crisis, but also to what I see as a capitalist system that is not working for the long term, for society. There's too much inequality.

I'm trying to create a model for a new version of capitalism that will have a long-term future. So quite ambitious, to say the least!

FIBRE'S BIG BEASTS

Here are the UK's major fibre providers that the smaller altnets are currently competing against

1. Openreach

The former BT monopoly now has full fibre deployed to around 18 million homes and businesses, and is adding more than a million a quarter. It aims to reach the vast majority of premises in the UK by the end of the decade.

2. Virgin Media O2/Nexfibre

Virgin Media has just over 16 million customers in largely urban areas. It's about a quarter of the way through upgrading its network to full fibre. Nexfibre – a joint venture owned by many of Virgin's investors – is adding another 5-7 million full-fibre lines in areas not currently served by Virgin.

3. CityFibre

A full-fibre wholesaler that now reaches more than 4 million premises. ISPs such as Sky, Vodafone and Zen use CityFibre's network. It's aiming to be the UK's third national network, reaching more than 8 million premises, although that would leave it far behind the top two in terms of overall coverage. CityFibre has been gobbling up smaller altnet rivals.

4. Netomnia/Brsk

These two altnets merged in 2024 and have a combined reach of just over 2 million premises. The company is looking to expand further, with ambitions to become the UK's largest altnet.

ABOVE **Openreach provides full fibre to around 18 million premises in the UK**

The A-List

The best products on the market, as picked by our editors

PC PRO A-LIST

PREMIUM LAPTOPS

Apple MacBook Pro M4

M4 beast from £1,599

from apple.com/uk

This M4 update to the already brilliant MacBook Pro line is an easy recommendation, so the big question becomes do you choose the 14in version from £1,599 or 16in from £2,499? And then how much do you upgrade, as Apple isn't afraid of high prices. But whatever you choose should last for years, and look great while it's doing it.
REVIEW **Issue 364, p50**

Apple MacBook Air M4

If you don't need the all-out power of the Pro, this is a brilliant, cheaper alternative despite the unchanged chassis and screen. **13in from £999, 15in from £1,199 from apple.com/uk**
REVIEW **Issue 368, p54**

Asus Zenbook S 14 OLED

Asus pairs a Core Ultra 9 288V with a 72Wh battery to produce a laptop that lasts almost 20 hours on a charge. What's more, this 1.2kg machine looks (and feels) the business. **From £1,750 from scan.co.uk**
REVIEW **Issue 362, p46**

Asus ProArt PX13

With AMD's new Ryzen AI 9 HX 370 inside, this 1.4kg compact powerhouse offers incredible amounts of power. Add a fantastic OLED screen and RTX 4070 graphics and it's a winner. **From £2,000 from uk.store.asus.com**
REVIEW **Issue 361, p50**

BUSINESS LAPTOPS

Dell Pro 13 Premium

Sheer quality from £1,452 exc VAT

from dell.com

Dell's business laptop series has a new name, but its commitment to build quality and astonishing levels of configuration remain the same. Here, you benefit from a 1.1kg weight and 24-hour battery life, with Intel's 200V vPro series there for easier remote management. Just make sure you avoid the cheap screen option.
REVIEW **Issue 368, p46**

Lenovo ThinkPad X1 Carbon Gen 12

The X1 Carbon range has stepped up a gear thanks to Intel's Core Ultra chips, and Lenovo matches it with the stunning build quality and keyboard you'd expect. **From £1,375 from lenovo.com**
REVIEW **Issue 358, p58**

Lenovo ThinkPad T14s Gen 6 (Snapdragon)

There's no better laptop if you want to try out Snapdragon, thanks to its combination of build quality, speed and battery life. **£1,500 exc VAT from lenovo.com**
REVIEW **Issue 360, p56**

HP OmniBook Ultra Flip

A top-quality 2-in-1 with a terrific 14in OLED panel, great build quality and superb battery life thanks to Intel's latest generation Core Ultra 7 processors. **From £1,699 from hp.com**
REVIEW **Issue 365, p46**

COPILOT+ PCs

Asus Zenbook A14

Sub-1kg style for an affordable £1,100

from uk.store.asus.com

It says something about this affordable and super-slim laptop that with its 14in OLED panel it could easily take pride of place in our premium laptops category. It has all the performance most people need and fantastic build quality.
REVIEW **Issue 367, p58**

Lenovo Yoga Slim 7x Gen 9

A Snapdragon X1E-78-100 makes this a nippy Copilot+ PC, and the battery lasts over 16 hours despite the demands of its top-quality 14.5in OLED screen. **£1,350 from lenovo.com**
REVIEW **Issue 361, p57**

Microsoft Surface Laptop, 7th Edition

The poster child for Copilot+ PCs offers quality, great looks and staggering battery life. **From £1,049 from microsoft.com**
REVIEW **Issue 360, p50**

Asus Zenbook S 15 OLED

With a price drop to £1,200 this 15.6in laptop becomes a viable competitor to the Yoga Slim 7x if you need a bigger screen. **£1,200 from uk.store.asus.com**
REVIEW **Issue 359, p52**

EVERYDAY LAPTOPS

Acer Aspire 14 A14-51GM

Compact power for £850

from acer.com

Want gaming power? Buy the version with RTX 2050 graphics for £850 (part code NX.KSVEK.005). Just care about value? Get a Core 5 processor and integrated graphics for £600 (part code NX.KRWEK.00B). Whichever you choose, it's a staggering laptop for the price.
REVIEW **Issue 359, p82**

NEW ENTRY

Asus Zenbook 14 OLED (UX3405)

If you can stretch past £1,000, this is a top-quality Core Ultra laptop with a superb 120Hz screen and great battery life. **From £1,099 from uk.store.asus.com**
REVIEW **Issue 359, p58**

Framework Laptop 13 (DIY Edition)

With a competitive price, modular approach and easy-to-repair ethos, you can pick and mix your perfect 13in laptop. **From £779 from frame.work**
REVIEW **Issue 360, p58**

MSI Prestige 13 AI+ Evo A2VM

Astonishingly good value whether you buy the Core 7 or Core 9 Ultra versions, this sub-1kg laptop packs a great screen, power and supreme battery life. **From £899 from currys.co.uk**
REVIEW **Issue 369, p60**

CHROMEBOOKS

Samsung Galaxy Chromebook Plus (2024)

Core 5 power for £749

from samsung.com

The first truly desirable Chromebook since the Pixelbook, this is a top-quality laptop from the all-metal chassis to the 15.6in Full HD OLED screen. And thanks to Intel's Core 5 120U processor, it's fast enough to last for years.

REVIEW **Issue 364, p65**

Acer Chromebook Plus 515

This Chromebook Plus laptop is all about value. With strong speeds thanks to Intel's Core i5-1235U processor, and a good-quality 15.6in panel with a 1,920 x 1,080 resolution, Asus' Chromebook Plus 515 is ideal for families, students and business users, providing mobility isn't your main priority as it isn't particularly light at 1.7kg. **£429 from currys.co.uk**

REVIEW **Issue 356, p82**

Acer Chromebook Spin 714

If you're looking for a convertible, this is the best choice around. Others may beat the 12th gen Intel Core i5 we tested for performance, but for features, design and bang for buck you won't find any laptop that can match this 2-in-1 for the money.**£799 from currys.co.uk**

REVIEW **Issue 356, p83**

MINI PCs

Apple Mac mini M4

Little monster from £599

from apple.com/uk

This is a big and timely update for the Mac mini, with a much smaller (and squarer) design that's easy to tuck behind a screen. But what lifts it above the pack is the astonishing power of the M4 and M4 Pro chips, with barely any cooling required. As ever with Apple the upgrade costs are high, but at least its starting price is reasonable.

REVIEW **Issue 364, p44**

Geekom A6 Mini PC

The Geekom A6 Mini PC steals the A8's place on our A List thanks to its sheer value for money. The A6 costs £220 less but doesn't compromise on quality or connectivity, and while the Ryzen 7 6800H is a step down from the Ryzen 9 8945HS in the A8, it remains a superb performer.

£499 from geekom.co.uk

REVIEW **Issue 367, p56**

Minisforum Venus UM790 Pro

Ignore its basic looks, for this compact system packs in a fast AMD Ryzen 9 7940HS processor, 32GB of DDR5-5600 RAM and 1TB SSD along with a generous selection of ports, including two USB-C 4 connectors. And the price is super-aggressive.

£549 from store.minisforum.uk

REVIEW **Issue 363, p91**

ENTHUSIAST PCs

Scan 3XS Edge iCue

Silent but deadly fast for £2,800

from scan.co.uk

With the RTX 5080 comes a refresh of best enthusiast PCs. The Scan is a shade slower than its Ryzen 9 9800X3D rival from Wired2Fire, but even at full pelt it remains astonishingly quiet.

REVIEW **Issue 367, p50**

CyberPowerPC Infinity Z890 Air

Don't have the money for the Scan? How about saving £900 on this well-built, compact PC based around a Core Ultra 7 265KF processor and Nvidia's RTX 5070 graphics? Upgrade to 5070 Ti for £150. **£1,900 from tinyurl.com/368cyberpower**

REVIEW **Issue 368, p61**

PCSpecialist Hydra R60S

This compact PC makes little noise but still packs a gaming and creative punch thanks to RTX 4060 graphics and AMD's older but speedy Ryzen 5 7500F. You can upgrade to an RTX 5070 when budget allows. **£999 from pcspecialist.co.uk/reviews**

REVIEW **Issue 368, p60**

ALL-IN-ONE PCs

HP Envy 34 All-in-One

£2,099 widescreen wonder

from hp.com

Built around a high-quality 34in widescreen – which is perfect for viewing two windows side by side thanks to its 21:9 aspect ratio – this also comes with Nvidia RTX 3060 graphics. We're big fans of the magnetic 16-megapixel camera, too.

REVIEW **Issue 335, p46**

Dell Inspiron 24 All-in-One

Despite being built to hit a price point, the Inspiron 24 All-in-One manages to look classy, include a good-quality, 1,920 x 1,080 24in panel and have enough power to breeze through a typical day's tasks. It even packs mod cons such as a 720p webcam. Superb value for money.

From £599 from dell.co.uk

REVIEW **Issue 350, p47**

Apple iMac M4

Anyone hoping for a 27in iMac will be disappointed, but everyone else should be delighted by this M4-powered all-in-one with its 24in 4,480 x 2,520 IPS panel. It's fast inside and out, too, with Thunderbolt 4 and Wi-Fi 6E both part of the package. **From £1,299 from apple.com/uk**

REVIEW **Issue 364, p48**

CREATIVE WORKSTATIONS

NEW ENTRY

Armari Magnetar M64T7-AW1650G4

Threadripping power for £8,329 exc VAT

from armari.com

AMD's Ryzen Threadripper 7980X is the star of this particular show, dominating our benchmarks with the help of 128GB of RAM, two 2TB Crucial PCI-E 5 drives in RAID0 configuration and AMD's Radeon Pro W7800 professional GPU. And it's all wrapped up in a custom Armari case with liquid cooling.

REVIEW **Issue 361, p92**

NEW ENTRY

Scan 3XS Evolve Studio Pro

Thanks to its combination of a Ryzen 9 9950X3D and GeForce RTX 5090, this will race through games – but it's also a fantastic choice for 3D animation and modelling. With top-quality components throughout and a gorgeous case, it will perform for years. **£4,167 exc VAT from tinyurl.com/369scan**

REVIEW **Issue 369, p48**

Apple Mac Studio

Now updated with your choice of M3 Ultra or M4 Max chips, this is the natural choice for professionals who rely on Apple hardware (or software). As with all Apple products, prices rocket once you add memory and storage, but this is a long-term investment. **From £1,749 exc VAT from apple.com**

REVIEW **Issue 369, p52**

TABLETS

Apple iPad Air M3

Languid power from £599

from apple.com/uk

It's hard to be too excited by this update as it's exactly the same design but with an M3 chip inside. But when the original was so damn good, whether in 11in or 13in variants, and Apple Intelligence is thrown in, it remains the best choice for the vast majority of tablet buyers.

REVIEW **Issue 368, p56**

Apple iPad Pro M4

The best tablet in the world becomes even better thanks to Apple's stunning M4 chip, a gorgeous OLED screen and the must-have accessory: the all-new Pencil Pro. But it comes with an obvious downside of cost, with the cheapest 13in incarnation costing £1,299. **From £999 (11in, 256GB) from apple.com**

REVIEW **Issue 358, p48**

OnePlus Pad 2

Last year the OnePlus Pad took its place alongside Apple's iPads on the A List – and this year it's done it again, with superb battery life of over 18 hours, a gorgeous design and great power making this new version an even better proposition. All for a price that's exactly right. **£449 from oneplus.com/uk**

REVIEW **Issue 364, p86**

EVERYDAY PHONES

NEW ENTRY

Google Pixel 9a

Why pay more? From £499

from store.google.com

If you can live without an optical zoom then it's hard to think of a reason to pay more for a phone. The AI features are genuinely useful, it's fast, the battery lasts forever, the camera is superb and the 6.3in OLED panel is a joy to gaze at.

REVIEW **Issue 369, p74**

NEW ENTRY

Nothing Phone 3a

Looking to get the best possible phone for around £300? This is it. Quite aside from Nothing's unique design, it features a gorgeous display and high-quality cameras – including an optical zoom that few phones in this price bracket can match. **£329 from nothing.tech**

REVIEW **Issue 368, p77**

Samsung Galaxy A55

Not the fastest phone on the market, but in return you get a high-quality 6.6in OLED display, excellent battery life and a trio of strong cameras. And you also get four years of feature updates. With a price that significantly undercuts the Pixel 8a, it's great value, too. **128GB, £364 from johnlewis.com**

REVIEW **Issue 358, p77**

PREMIUM PHONES

Samsung Galaxy S25 Ultra

AI in your hand from £1,249

from samsung.com/uk

So good it tempted our reviewer – an iPhone devotee – to move to the other side. That's thanks to the faultless hardware, brilliant photography performance and Samsung's slick AI, not to mention the integrated S Pen stylus. It's not cheap, but you're buying for the long term with seven years of OS updates.

REVIEW **Issue 367, p70**

Honor Magic V3

With the Magic V3, not only does Honor make foldable phones as slim as flagship phones but also as affordable – so long as the £300 discount voucher still applies, as shown in the price here. What's more, the cameras and both OLED panels are superb. **£1,400 after discount from honor.com**

REVIEW **Issue 362, p62**

Apple iPhone 16 Pro

Even without Apple Intelligence, the introduction of a 5x optical zoom, classy 6.3in OLED panel and Apple's ludicrously fast A18 Pro chipset make this the best update to an iPhone Pro for years. And if you need one more reason to buy, how about its much improved battery life? **128GB, £999 from apple.com/uk**

REVIEW **Issue 363, p70**

EVERYDAY MONITORS

Iiyama ProLite XUB3293UHSN-B5

32in 4K bargain, £429

from currys.co.uk

The fact that this 31.5in IPS monitor could compete so well against Eizo's alternative (*see below*) says it all. Great colour coverage in sRGB and DCI-P3, USB-C and RJ45 inputs, plus solid build quality add up to a bargain.

REVIEW **Issue 357, p88**

AOC Q27B3CF2

AOC's relentless focus on value delivers a 27in 1440p screen with a high-quality IPS panel that costs £200 including VAT – and also packs in a USB-C port. Those are almost the only features you get, and the OSD is awful, but at this price we're not complaining. **£200 from amazon.co.uk**

REVIEW **Issue 360, p77**

Acer Verso B277 Ebmiprzxv

This is a basic but high-quality monitor, delivering colourful images across its 27in Full HD diagonal. You don't get USB-C docking, but it includes VGA, HDMI and DisplayPort inputs, plus a two-port USB hub. **£149 from tinyurl.com/357acer277**

REVIEW **Issue 357, p84**

PROFESSIONAL MONITORS

Eizo FlexScan EV3240X

Stunning 4K quality, £1,206

exc VAT from photospecialist.co.uk

With images that whack you between the eyes as soon as you lift it, fully assembled, from its box, this 32in 4K monitor is our top choice pick for anyone willing to make such a hefty long-term investment.

REVIEW **Issue 357, p91**

Eizo ColorEdge CG2700X

A brilliant choice for professional designers, whether working solo or in teams, thanks to its dedication to providing accurate colours across potentially years of life. It's also bang up to date for connectivity, with USB-C and RJ45 making it easy to manage, too. **£2,149 exc VAT from wexphotovideo.com**

REVIEW **Issue 357, p90**

BenQ PD2706U

If you can't stretch to Eizo budget levels then this 4K 27in screen is definitely worth investigating. It has several features aimed at professionals, including a Hotkey Puck to switch between profiles, plus great coverage of the sRGB and DCI-P3 gamuts. **£333 exc VAT from scan.co.uk**

REVIEW **Issue 357, p86**

WEBCAMS

Logitech MX Brio 705 for Business

Consistent brilliance for £219

from logitech.com

Consistent image quality in all lighting conditions coupled with top build quality and nifty features – such as a presenting mode for items on your desk – make this a fantastic all-round choice.
REVIEW **Issue 356, p68**

Logitech Brio 105 for Business

While you can buy 1080p webcams for a third of the Brio 105's price, they won't hold a candle to the Logitech webcam's quality – especially in low-light conditions, such as one candle. It's also easy to manage, for businesses and individuals.
£45 from logitech.com
REVIEW **Issue 360, p77**

Obsbot Tiny 2

This portable 4K webcam delivers for quality, design and sharpness, and it comes with a shedload of advanced features, including dynamic zoom and subject tracking. The only real downside is that it has a price that reflects its premium ambitions.
£329 from amazon.co.uk
REVIEW **Issue 352, p75**

HOME OFFICE PRINTERS

HP OfficeJet Pro 9135e

Do-it-all inkjet for £193

from printerbase.co.uk

This versatile inkjet all-in-one – which includes a 35-page ADF – pumps out high-quality prints at laser-rivalling speeds. Likewise scans and copies. Print costs are reasonable, too.
REVIEW **Issue 365, p85**

Epson EcoTank ET-2865

As usual with ink tank printers, you don't get many frills with the Epson EcoTank ET-2865 (so no ADF or screen). What you do get is incredibly low running costs of 0.5p for colour and 0.2p for mono, plus high-quality prints and scans.
£233 from uk.insight.com
REVIEW **Issue 365, p84**

Canon i-Sensys LBP243dw

Everything you could want from a mono laser printer – it doesn't come with a scanner – the LBP243dw produces excellent results at speed. You also get Wi-Fi and wired networking. **£186 from printerbase.co.uk**
REVIEW **Issue 365, p88**

WORKGROUP PRINTERS

Canon Maxify GX6550

Ink tank all-in-one for £392 exc VAT

from canon.co.uk

Designed to fit in tight spaces, this all-in-one includes a highly effective ADF and backs it up with high-quality prints at 24ipm in our tests. Running costs are superb, too.
REVIEW **Issue 350, p58**

Brother HL-L9430CDN

This laser printer (not an all-in-one, so there's no scanning or copying functionality) is a great choice for a busy office, producing sharp black text and making a good job of colour graphics as well. All while doing so quickly with a competitive price per page. **£415 exc VAT from printerland.co.uk**
REVIEW **Issue 353, p84**

Xerox B315DN

A fine alternative to the Brother and Canon, this mono laser multifunction printer produces superb results at great speed – 27.5 pages per minute in our 50-page test, which includes the spool time. It's similarly quick for scans, with a dual-CIS ADF to speed up double-sided copies. **£238 exc VAT from printerbase.co.uk**
REVIEW **Issue 341, p87**

WIRELESS ROUTERS

Netgear Nighthawk RAXE300

Fast Wi-Fi 6E router, £350

from amazon.co.uk

The RAXE500 is faster than the RAXE300, but in practice we doubt you would notice – this tri-band router still delivered speeds between 50MB/sec and 150MB/sec in our tests. And it's packed with features, too. At £150 cheaper than its bigger brother, we think it hits the Wi-Fi 6E sweet spot.
REVIEW **Issue 341, p68**

Netgear Nighthawk RS700S

Make no mistake – you won't get stunning speeds out of this Wi-Fi 7 router today. But if you must buy a router now and want future-proofing, this is a solid choice. But honestly, we would recommend that you wait.
£800 from netgear.com
REVIEW **Issue 353, p76**

Asus RT-AX59U

You can buy cheaper Wi-Fi 6 routers – such as the D-Link Eagle Pro AI R15 for £55 – but Asus' well-priced offering delivers strong performance along with lots of control and exceptional VPN support. **£125 from uk.store.asus.com**
REVIEW **Issue 350, p57**

MESH WI-FI

TP-Link Deco XE200

Clever Wi-Fi 6E for £400

from amazon.co.uk

There are cheaper Wi-Fi 6E meshes, but the XE200 wins for its superb download speeds, excellent coverage and the fact that older clients reap benefits of 6E, not just new ones. And a two-pack (code B0BKTDPWC8) should be enough for most premises.
REVIEW **Issue 349, p65**

Netgear Orbi 770

If you're eager to upgrade to Wi-Fi 7 then the Orbi 770 is the best mesh option yet. Its speed and range are both excellent, with a twin-pack covering 420m² (says Netgear), and the wired connectivity superb: four 2.5GbE connectors on the router unit, two 2.5GbE ports on the satellites. But it ain't cheap. **2-pack, £600 from amazon.co.uk**
REVIEW **Issue 364, p70**

Linksys Velop Pro 6E

Ironically, this Wi-Fi 6E router will get the most out of your non-Wi-Fi 6 devices thanks to its use of the 6GHz network for station-to-station traffic. And you only need two units for rock solid performance across a three-bedroom house. **2-pack, £380 from amazon.co.uk**
REVIEW **Issue 350, p54**

BUSINESS WI-FI

NEW ENTRY

Ruijie Reyee RG-RAP73Pro

Wi-Fi 7 AP, £201 exc VAT

from broadbandbuyer.com

The RG-RAP73Pro delivers a wealth of features and top Wi-Fi 7 performance at a tempting price. Broadbandbuyer's provisioning service makes light work of deployment, and the free Ruijie Cloud service offers top-notch remote management.

REVIEW **Issue 369, p103**

TP-Link DR3650v

"Business Wi-Fi" doesn't do justice to this all-in-one communications, security and networking solution, which combines a dual-band AX3000 access point with WAN redundancy, failover services and a treasure trove of features. **£208 exc VAT from broadbandbuyer.com**

REVIEW **Issue 368, p103**

EnGenius ECW526

The ECW526 is a top choice for SMBs looking to make the move to Wi-Fi 7 as it combines a great feature set at a tempting price. Cloud management services are extensive, and its potent Qualcomm CPU and 10GbE port deliver superb wireless performance. **£225 exc VAT from solwise.co.uk**

REVIEW **Issue 366, p102**

NAS SERVERS

NEW ENTRY

NEW ENTRY

Synology DiskStation DS1823xs+

10GbE NAS, £1,413 exc VAT

from broadbandbuyer.com

This stalwart retains its top spot on the A-List thanks to its powerful performance (courtesy of a Ryzen chip), huge capacity via eight LFF/SFF hot-swap SATA bays and an unmatched set of business-friendly apps. And it's all built on Synology's DSM 7.2, which is focused on data security.

REVIEW **Issue 368, p99**

Asustor Nimbustor 4 Gen2 AS5404T

Built for SMBs and enthusiasts who demand the best performance, the AS5404T is a four-bay NAS that offers much more than most, with some nice surprises under its standard-looking exterior. **£441 (£529 inc VAT) from amazon.co.uk**

REVIEW **Issue 369, p88**

Qnap TS-264

The Qnap TS-264 is aimed at those who want a bit more from a traditional two-bay NAS. It's effectively the two-bay version of the excellent four-bay TS-464, and like its sibling provides strong speeds over its pair of 2.5GbE ports – and includes two M.2 NVMe slots. **£391 (£469 inc VAT) from ukstore.qnap.com**

REVIEW **Issue 369, p86**

VIDEOCONFERENCING

Biamp Parlé VBC 2800

Go big for £2,918 exc VAT (MSRP)

from midwich.com

We thought the VBC 2500 was a great VC room bar, and the new VBC 2800 delivers Biamp's undeniable expertise to larger meeting rooms. Video and audio quality are outstanding, speaker framing is super fast and the smart combination of dual camera lenses makes sure everyone is in the big picture.

REVIEW **Issue 364, p98**

Owl Labs Medium Room Solution

The Owl 4+ and Owl Bar partnership offers smart tracking and dynamic split-screen views to ensure everyone is in the picture, while the Whiteboard Owl adds extra professionalism to presentations and training sessions. **Owl 4+, Owl Bar, TV mount, £2,999 exc VAT from owllabs.co.uk**

REVIEW **Issue 364, p100**

Ricoh Meeting 360

Ricoh's Meeting 360 is up against stiff competition in the panoramic meeting hub market but stands out for its excellent build quality and generous three-year warranty. It's easy to use and delivers good video and audio quality, while the smart app allows you to create a view for every occasion. **£744 exc VAT from amazon.co.uk**

REVIEW **Issue 364, p101**

SCANNERS

Xerox N60w Pro Scanner

Speed demon, £766 exc VAT

from tradescanners.com

The N60w Pro offers tremendous value and versatility. It delivered up to 67ppm in our tests with great output quality, offers a plethora of connection options and makes walk-up scanning a breeze.

REVIEW **Issue 358, p101**

Brother ADS-4500W

Ideal for small businesses, the ADS-4500W offers a fine set of walk-up scan features and its output quality is beyond reproach, while Brother's Print&Scan app delivers great scan workflow management options. **£295 exc VAT from printerbase.co.uk**

REVIEW **Issue 358, p98**

Epson WorkForce DS-800WN

A flexible desktop scanner with 50ppm pace and lots of connection options. Epson's software provides great scan management features, and support for Epson's Open Platform is a boon for document management. **£656 exc VAT from ballicom.co.uk**

REVIEW **Issue 365, p103**

SECURITY APPLIANCES

Firewalla Gold Pro

Top-value protection for $899 (£676)

from firewalla.com

A great choice for SMBs that delivers a wide range of security features at a tempting price. Our 10GbE tests show it can easily cope with high demand, and don't worry about subscriptions as the price includes all security services and lifetime updates.

REVIEW **Issue 364, p103**

DrayTek Vigor 2927Lax-5G

This affordable security router is a particularly good choice for smaller businesses. It offers always-on internet access thanks to an unbeatable set of WAN redundancy features whilst building in still-speedy Wi-Fi 6 services. **£667 exc VAT from broadbandbuyer.com**

REVIEW **Issue 360, p98**

WatchGuard Firebox M390

The Firebox M390 combines strong performance with an incredible range of security measures at a competitive price. It's easy to deploy and a cloud portal delivers remote management and monitoring services. **Appliance with 1yr TSS subscription £4,273 exc VAT from broadbandbuyer.com**

REVIEW **Issue 360, p100**

SECURITY SOFTWARE

Avira Prime
Avira wins for all-round AV performance, plus a solid VPN, for a fair price. Watch out for a second-year hike to £91, though.
First year: 5 devices, £52 from avira.com
REVIEW **Issue 366, p84**

Bitdefender Total Security
A long-term award winner in our security suite Labs, Bitdefender continues to charm for its consistent AV performance, solid feature set and extremely competitive price.
5 devices, 1yr, £20 from store.pcpro.co.uk
REVIEW **Issue 366, p85**

Avira Free Antivirus
There's absolutely no need to pay for a full security suite if you only want antivirus protection, and Avira is our top choice simply due to its excellent and consistent performance in tests.
Free from avira.com
REVIEW **Issue 366, p89**

VPNs

Surfshark
Reliably fast and goes out of its way to ensure that international streaming services work. Surfshark has a credible track record for privacy, too.
£55 for 27 months from surfshark.com
REVIEW **Issue 360, p87**

NordVPN
One of the best all-purpose consumer VPN services around, and the paid-for version is packed with features – from anti-malware tools to a rather clever mesh file-transfer system.
£94 for 27 months from nordvpn.com
REVIEW **Issue 360, p85**

Proton VPN
A great VPN in its own right, but also the best free VPN service as you get unlimited data. Instead, Proton restricts which endpoints you can access to only three countries: the USA, the Netherlands and Japan. **Free from protonvpn.com**
REVIEW **Issue 360, p86**

LINUX DISTROS

Ubuntu
A fine choice for Windows switchers thanks to its familiar design, with regular six-monthly updates and a Long Term Support version. **Free from ubuntu.com**
REVIEW **Issue 367, p92**

Fedora Workstation
One of the longest-established distros, and with a strong link to Red Hat Enterprise Linux, Fedora Workstation will particularly appeal to business migrators. **Free from fedoraproject.org**
REVIEW **Issue 367, p85**

Linux Mint
There's a good reason this is a popular choice for Windows 10 refugees, including a familiar "Start menu", and it's easy to give it a trial before committing. But consider Zorin OS, too. **Free from linuxmint.com**
REVIEW **Issue 367, p86**

ON-PREMISES BACKUP

Nakivo Backup & Replication 10.11.2
Perfect for SMBs that want the freedom to choose their host system. It supports an incredible range of hardware platforms and OSes and is packed with data protection features. **Enterprise, 10 servers, perpetual licence, £1,118 exc VAT from nakivo.com**
REVIEW **Issue 362, p100**

Veritas Backup Exec 23
Backup Exec 23 is easy to manage, provides valuable ransomware protection and the subscriptions are great value. **Simple Core Pack, 5 instances, £498 exc VAT per year from uk.insight.com**
REVIEW **Issue 362, p101**

NETWORK MONITORING

Progress WhatsUp Gold 2024
A great SMB choice as it presents a clear picture of your network and is available in a wide range of licensing plans. It's a cinch to deploy, doesn't require a lot of host resources and the new features make it even easier to customise. **Enterprise, 50 devices, £1,177 exc VAT per year from whatsupgold.com**
REVIEW **Issue 366, p100**

Park Place Technologies Entuity 22
An impressive toolbox of monitoring services all easily managed from a web console that offers a wide range of informative dashboards. **From $150 per node/year from parkplacetechnologies.com**
REVIEW **Issue 366, p99**

VOIP SERVICES

NEW ENTRY

3CX Phone System 20 Update 5
Deployment options are extensive, call-handling features are excellent and, although you'll need to source a SIP trunk, it's incredibly affordable.
Enterprise, 8SC, £385 exc VAT per year from 3cx.com
REVIEW **Issue 369, p98**

NEW ENTRY

TelephoneSystems.Cloud
Ideal for businesses that don't want any unpleasant billing surprises, with an impressive range of call-handling features. **From £11 exc VAT per user per month from telephonesystems.cloud**
REVIEW **Issue 369, p100**

ENDPOINT PROTECTION

WithSecure Elements Endpoint Security
A comprehensive set of protection measures for a great price, easily managed from a cloud portal. It supports a wide range of devices and the Luminen tool delivers AI-powered reporting services that present detailed summaries of events with a click.
100-499 devices, £37 exc VAT each per year from withsecure.com
REVIEW **Issue 363, p101**

Sophos Intercept X Advanced
An unbeatable range of tough security measures. Deployment is a breeze, and a multitude of security policies make it highly flexible. **100-199 users, £48 exc VAT each per year from enterpriseav.co.uk**
REVIEW **Issue 363, p98**

REMOTE SUPPORT

NetSupport Manager 14.1
Sets the standard for on-premises hosted support for local and remote workers. It delivers a remarkable range of features and its one-time cost per seat will appeal to businesses concerned about subscription fees. **1-500 systems, perpetual licence, £10 each exc VAT from netsupportmanager.com**
REVIEW **Issue 361, p100**

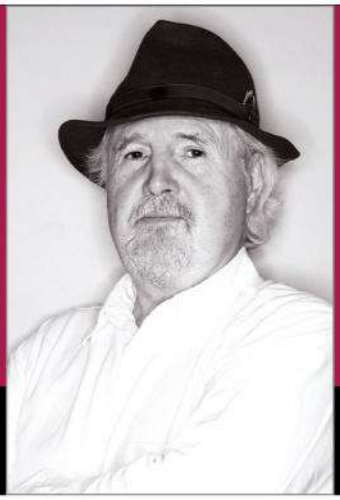
ISL Online Standard
Perfect for SMBs wanting cloud-based support. Features and access security are excellent, as are its flexible licensing plans. **Standard Cloud/One user, £287 exc VAT per year from islonline.com**
REVIEW **Issue 361, p99**

CLOUD FILE-SHARING

Progress ShareFile Premium
Progress ShareFile Premium will appeal to SMBs seeking affordable and easily managed cloud collaboration services. It offers plenty of app integrations plus support for large file sizes, and the AI-powered features deliver smart security measures. **£19.90 exc VAT per user per month billed yearly from sharefile.com**
REVIEW **Issue 367, p98**

Dropbox Business Plus
Collaboration tools, app integrations and a huge maximum file size limit – plus malware scanning and data classification – make this a great choice. **£18 exc VAT per user/month billed yearly from dropbox.com**
REVIEW **Issue 367, p96**

We live in way too interesting times



Dick Pountain is editorial fellow of *PC Pro* and pronounces DOGE as "doggie", like that creepy Shiba Inu dog meme. @dick-pountain

Whether it's world leaders, customer support teams or Chromebooks, the world is conspiring to make my life interesting in all the wrong ways

Some 26 years ago, back in May 1999, I opened this column thus: "It's said there's an ancient Chinese curse, 'May you live in interesting times!' Actually it's been said by me at least twice before."

Well, it looks time to trot it out for a fourth outing, though nowadays I can check its truth using my old friend ChatGPT: "No record of this phrase (or anything close to it) exists in classical Chinese literature: the earliest known attribution is from British sources in the 20th century, a 1936 speech by Sir Austen Chamberlain (brother of Neville) who claimed to have heard it as a Chinese curse, but it seems more like a Western invention made to sound exotic or wise." So, I've been peddling fake news for a quarter of a century, but I don't feel too guilty as everyone seems to be doing it.

The financial turmoil created by President Trump's tariff barrage purports to be against a whole world ripping off the USA through unfair trade, but we all know it's really about China. Many of us believe Trump has made a monumental blunder that will ultimately help China to economic dominance. The *Wall Street Journal* expressed it thus: "What a fabulous change in fortunes for the Chinese leader. Mr Trump has taken an axe to the economic cords that were binding the rest of the world into an economic and strategic bloc to rival Beijing – and at precisely the moment many countries finally were starting to re-evaluate their economic relationships with China."

I've covered semiconductor fab, Taiwan invasions and DeepSeek in recent columns so let's not go there again, except to guess that Trump's shenanigans could cause interest rate, futures and bond market chaos that may bring down the intricate house-of-cards finance of the AI bubble corporations (already under siege from IP lawyers). Instead I'd rather talk about how the "interesting times" are affecting my own everyday activities.

> "The craven way the big Silicon Valley corporations crowded onto Trump's rattling gravy-train will haunt them for years"

For many years my online presence, apart from my own website, consisted of Flickr for posting photos and Facebook for chatting/arguing/posing with friends. No longer, as my online self has been shattered into a dozen fragments, none of which has quite the same scope or satisfaction as before. Facebook started to deteriorate for me a couple of years ago as old friends left and unasked-for content increased; now, since Zuck did a Musk on it by removing moderation it's becoming intolerable. As a result, I've begun to work on building a following on both BlueSky and Substack.

BlueSky is full of left-leaning refugees from the steaming pit that X has become: lots of excellent, *sympa* content, in fact too much to read it all and unanimous enough to risk boredom. I joined Substack years ago hoping to get paid for some of my musings, but that didn't work out so I forgot it until now, when it appears to be changing into something different. It's becoming a social platform to rival Facebook, an alternative refuge for X-iters and I actually find it more interesting than BlueSky, but with one huge reservation: its structure and user interface remain totally baffling. Is it a mailing list or a website, a forum or what? Do I add posts or notes, and where will the comments arrive?

My efforts in computer-generated music are now scattered among a host of platforms including SoundCloud, YouTube, NoisePit, Bandcamp and GrungeDump (I may have invented one of those) and it remains stubbornly anti-viral on all of them. YouTube is still my main source of entertainment, from genial luthiers to hilarious espresso gurus, Rick Beato's music interviews to Jon Stewart's *Weekly Show*. I even watch some movies there for less than other paid platforms (I recently found *Lonesome Dove* for free).

> "My online self has been shattered into a dozen fragments, none of which has quite the same scope or satisfaction as before"

The interestingness seems to be spreading from online matters to offline. A few months ago my Chromebook finally ran out of support, so I bought a new Asus CX340 laptop(cheap, way faster and nicer, since you ask). BT announced that it was killing off my analogue landline early, meaning a new hub, and that my mobile account should be moved to EE. While trying to surf such unwelcome disruptions I found several websites started playing up – I became adept at navigating poorly implemented two-factor authentication schemes that trap you into endless loops of passcode tennis, and discovered a new game called "hunt the human" while traversing the maze of AI chatbots that firms now erect in the name of Help.

Shall I end on a cheerful note, that things can only get better? It's getting ever harder to believe that. Once the DOGE-days are over, assuming some kind of sanity is restored, then the craven way the big Silicon Valley corporations crowded onto Trump's rattling gravy-train will haunt and taint them for years to come.

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Forget AI and robots: lockers are the future

Nicole Kobie is *PC Pro*'s Futures editor. Her other favourite app is Rightmove, because she's middle-aged now. @njkobie

Nicole has found the secret to productivity, and it has nothing to do with advanced technology. It's all about one simple innovation in sending parcels

I have watched cars flying, taken a ride in a driverless taxi and crossed the Firth of Forth on an automated bus – but the innovation I'm most impressed with is app-connected delivery lockers.

If you're not familiar with these genius inventions, they're huge metal boxes from a company called InPost. You'll find them tucked away near shops and in car parks, covered in little doors with a scanner and screen on the front. Need to pick something up? Scan a QR code, a door pops open and there, as if by magic, is your parcel. Sending a parcel is even better – you don't even need to print a label.

Amazon has similar lockers that connect to your phone via Bluetooth, the door swinging open as if the machine was expecting you. You get cheaper or even free shipping when using an Amazon locker for deliveries.

Royal Mail is planning something similar, with solar-powered, barcode-scanning red pillar boxes featuring a hatch that pops open to accept parcels. Part of the organisation's plans to nab a slice of parcel post that's risen along with online shopping and second-hand selling, it's a marvellous remake of a classic design. Though only five boxes are currently being trialled, fingers crossed that they work well enough to be rolled out more widely.

> "Need to pick something up? Scan a QR code, a door pops open and there, as if by magic, is your parcel"

I don't have a local Post Office, despite living in central-ish London. My nearest one inevitably has a massive queue. To avoid wasting time, I've been printing Royal Mail labels at home and taking my parcels to a drop box at a nearby industrial estate, but I've been stymied by returns that don't come with a full label, only a QR code to get one at the Post Office.

Even worse, some returns to online retailers require me to head to a shop with Evri service. But where? Our local Tesco randomly stopped taking Evri pickups and deliveries, making it impossible for me to send back any regretted purchases.

Another reason people love delivery lockers is avoiding courier chaos. We all have nightmare stories of packages gone missing or showing up in ridiculous places. Earlier this year, I got a photo of a parcel, purportedly showing it delivered on my doorstep. Except that it wasn't my doormat or my door; it was a different building on our estate. My husband went door to door in a neighbouring building to match the image to reality, but mysteriously the lady who answered the door swore she didn't have it. Then there's UPS: it just doesn't come to our address. Couriers claim to buzz our flat, but I work from home – lads, you were never here.

I actually like our posties and our local Evri delivery dude, who not only manages to deliver packages without damage, but smiles even after walking up three flights of stairs.

And that's the downside: such lockers are another way we're pushed into interacting with machines rather than people, like automated checkout tills. I'd rather have a chat with my postman or say hello to my Evri guy. I wish I could get to know the Post Office staff. But when faced with a queue of irritated customers, no retail worker can be expected to offer any kind of cheerful human interaction.

If I only needed to send the odd package, this wouldn't be a problem. But as the mother of a toddler that outgrows clothing at a shocking rate, the Vinted marketplace is one of my most used apps. I use the eBay rival to sell whatever clothing survives my daughter's knee-tearing tripping and her artistic proclivities – just because paint says washable doesn't mean it is.

This means I frequently have parcels to send and pick up from my local InPost lockers, which are handily a few minutes' walk down the canal. I no longer have to trek to the Post Office and wait in line before walking back again. I don't have to print labels. And I don't have to jaunt from shop to shop in search of a functioning Evri pickup.

> "The benefits are so profound to my life that I am full of forgiveness for my connected lockers and any other tech that makes my life easier"

It perhaps reflects poorly on me to say this, but app-powered lockers have changed my life.

Now, I should stress that these systems are often incredibly disappointing. We get a terrible mobile signal by our local Amazon lockers, meaning you need to stand in the middle of the car park watching for incoming vehicles while you await a connection to the blue monolith of package-storing boxes.

And InPost's app tells lies. It's supposed to track how many individual lockers of each size are available, saving you from lugging a big parcel all the way there only to find all the large lockers are full. It's a nice idea, but every time I fact-check the app against reality, it's wrong.

But I can forgive such tech foibles. The benefits are so – embarrassingly – profound to my life that I am full of forgiveness for my connected lockers and any other tech that makes my life easier. We don't need perfection, just genuine usefulness.

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The Phoney War with Virgin Media

Barry Collins doesn't have a landline, but you can email him at barry@mediabc.co.uk. Especially if you're a full-fibre provider in the Sussex area.
@bazzacollins

It's 2025 and apparently I must have a landline I don't want, along with a tiny lump of plastic and wires

The sadistic part of me almost looks forward to my 18-monthly wrangle with Virgin Media's retention department.

It normally follows a familiar pattern. Virgin sends me a contract-ending reminder, saying it will be charging me the price of a Range Rover from next month. I tell Virgin I'm not prepared to pay any extra, we spend a couple of hours arguing the toss, I threaten to leave about six times, and it eventually caves and renews at roughly what I was paying in the first place. It's like rows with my other half, except she's the one threatening to leave and I always end up paying (I'm available for weddings, bar mitzvahs, etc).

This year's haggle started off following the familiar script. How about we give you more speed for more money? I don't need more speed. OK, how about we give you the same speed for the same money, and we'll throw in a telephone line with that? That will do nicely, but I don't want the telephone line. Shall I proceed with this? Sure. I chalk up another successful negotiation, light a cigar.

"I would also like to keep you informed that there would be a one-off activation fee of £35 for the landline."

I choke on my cigar. "I don't need a landline."

"Unfortunately, the discount comes with the bundle."

"OK, cancel my deal then."

"Barry, let me speak to my manager about this, as I genuinely want to help you on this."

> "It's like rows with my other half, except she's the one threatening to leave and I always end up paying"

Of course you do, sunshine. You pop off for a chinwag with Richard Branson (or whoever's running the show these days), and I'll be here working out how to get cigar ash stains out of my jeans. He comes back a few minutes later. Apparently, he can waive the activation fee for something I won't activate. Praise be.

We then spend the lifetime of a minor royal going through the Ts&Cs, confirming this and that, reviewing documents, when the Virgin chap asks: "Could you confirm if next Tuesday would be a good day to receive the adapter for the Hub?"

"What do I need an adapter for?"

"It's for the telephone line. You needn't connect it but you can just keep it, if you change your mind about connecting it later."

"I'm never going to need a landline."

"This particular deal has the landline connection with it. I won't be able to just cancel it as part of the bundle."

And so, in the year of the Lord 2025 – the very same year that Openreach is writing to millions of pensioners telling them they're going to rip out their landlines because they're yesterday's technology – Virgin Media resolutely refuses to renew my broadband connection without one. Even though I've told the chap that I do not, will not, won't ever want a landline ever again ever, he sends me a lump of plastic and a cable through the post that's going straight to landfill. A waste of time, money and the planet's resources, all because Virgin's sales staff have less leeway than a death row prisoner, and some algorithm somewhere says they'll squeeze more money out of me once I start ringing my nan in Australia using a phone THAT I DON'T EVEN OWN ANY MORE.

> "A waste of time, money and the planet's resources, all because Virgin's sales staff have less leeway than a death row prisoner"

It's baffling how bad Virgin Media is at this stuff. It routinely records rotten scores for customer service and value for money in our Excellence Awards and other surveys, because of stunts like this. It's dismal, and I only put up with it because I basically have no other choice (I have two different broadband providers supplying my home/home office and because I want each of those to be high-speed and on different infrastructure, Virgin Media has to be one of those for the time being).

They didn't just send me a lump of plastic I didn't want, by the way. They failed to activate my new contract, overcharged me, promised to refund me, and a fortnight later still haven't activated the new contract nor honoured said refund. They're threatening to overcharge me for next month's bill now, too.

Virgin Media said in a statement: "We offer our customers a wide range of bundles at different price points and regularly offer deals that they can choose to take advantage of. This is a natural part of a competitive marketplace and gives consumers the opportunity to shop around and agree a package which works for them."

Trust me, I'd love to shop around. And with Openreach threatening to finally lay full fibre in our neighbourhood in the coming months, by the time I'm haggling over my next contract I will be. Assuming Virgin ever get round to activating my contract, that is.

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Readers' comments

Your views and feedback from email and the web

Dumb and dumber

Jon Honeyball's account of being tired of dumb items (*see issue 368, p110*) certainly resonates with me as the race to get something to market and "sort out the bugs later" increasingly becomes the norm.

My own "smart" Sony TV will only grudgingly talk to my LG sound bar after a lot of messing with setup procedures (and clearing the cache, for some reason). Apparently this is due to Sony and LG jointly throwing their toys out of their respective prams.

My two printers often work flawlessly until they suddenly either decide to sulk or try to pick paper from a non-existent paper tray or (very often with the Epson) to print everything across several sheets.

Add to this, a managerial necessity by Microsoft for constant unwanted updates to provide "an enhanced experience" and extract even more billions from the public and we find ourselves at the same state that car manufacture was in the 1950s – you couldn't simply buy a car and drive it, you had to be very knowledgeable in fault finding and maintenance, too.

Gordon Jackson

ABOVE Almost all tech products are reliant to some extent on Chinese components

UK-friendly PC?

Is it possible to run a computer that doesn't have tech from a hostile country, including the US?

Stephen Harper

Editor-in-chief Tim Danton replies: You can definitely avoid US-made hardware or software (Linux and open source is your friend), but if you're counting China in your list of hostile countries, then no. We explored our reliance on China at the start of the Covid pandemic in a feature, "Can tech survive without China?" (*see issue 308, p28*), which is still worth a read today.

Kindle swindle?

Barry Collins alleges that "the Kindle's not a swindle" (*see issue 368, p22*), but I beg to disagree. I own a Kindle, but a lot of the books I want to read are out of copyright anyway. I got bored with paying anywhere from 99p to several pounds to download a book that ought to be free, so acting on a recommendation from the *PC Pro* podcast "hot hardware" I bought myself a Boox Note Air 2.

Now, I can read classic titles for free, downloaded from Project Gutenberg or the Internet Archive – and the Note Air's 10in screen is big enough to read PDFs. But because it's basically an Android tablet, I can also use the Kindle app if I want to read Amazon content. Even better, my local library has an ebook borrowing service, so I can borrow and read copyright content free of charge. And the Note has a stylus so I can annotate books.

Why pay the "Amazon tax" when other e-readers are available?

Tim Morris

Beauty in symmetry

I enjoyed Barry's recent column (*see issue 367, p22*) about how ISP routers are limiting speeds. However, I'd also like to bring up the way BT Openreach is massively limiting upload speeds. My block of flats was recently enabled for FTTP with both CityFibre and Openreach – I was shocked at the difference in upload speeds, with only CityFibre offering symmetric speeds.

Star letter

Apple vs Google apps

Steve Cassidy is obviously not an app developer or he would know that there is a world of difference between the testing carried out by Apple and the testing (not) carried out by Google (*see issue 368, p104*). When you seek to have an app listed on the App Store, you have to supply credentials on the Apple Connect website for Apple to actually run your app. I know for a fact that they do this because I once changed the test login for one of my apps without updating the developer info on Connect and very shortly got a message back from Apple stating that they couldn't log into my app.

Generally for a new app, there's a wait of around two days from submitting an app to the App Store until it is listed. In contrast, when you submit an app to the Google Play Store, your app is available for download within seconds of being submitted. Perhaps Google has some scanning software to do rudimentary checking for malware, but this doesn't include actually running the app. For this reason, I advise my friends and family to prefer iPhones to Android phones. Having the latest gizmos on your phone for a few pounds less (or the "mug's eyeful" as Alan Sugar once so cynically put it) is not worth taking a risk with the sensitive information held on your phone.

Of course, Apple is not fully testing the functionality of your app, but at least someone there is actually loading the app, logging in to it and making sure that malware is not unleashed on your device, whereas I can't believe that Google is doing anything but the simplest verification, and I suspect not even that.

He also states that it's difficult to get in touch with the developer of an app, but again, Apple insists that a support link is provided. This is published in the App Store and Apple checks that the contact details you provide are valid.

I accept that businesses should not be reliant on an app without performing their own due diligence, but App Store apps are undoubtedly more secure than their Android cousins.

Brian C Preece

Editor-in-chief Tim Danton replies: Thanks for your feedback, Brian. I hadn't appreciated there was still such a difference beween Apple and Google when it comes to checking the integrity of apps, and it flags yet another reason why businesses need to tread carefully.

This month's star letter writer wins a Cherry Stream Desktop Comfort keyboard and mouse wireless set, worth £80. For a chance to win one, email letters@pcpro.co.uk

I haven't seen this covered too much but it just seems an unnecessary limitation and makes such a difference to power users.
Alan Robertson

News and features editor Barry Collins replies: We covered this very issue in our recent interview with Openreach's director of network technology, Trevor Linney (*see issue 367, p12*). Openreach is in the process of migrating from the asymmetric GPON to the symmetric XGS-PON, which bumps (shared) speeds to 10Gbits/sec in both directions. Whether Openreach actually decides to offer symmetric connections is another question, but pressure from rivals such as CityFibre might force its hand.

Linux ideas

I greatly enjoyed reading the piece comparing the various Linux distros out there (*see issue 367, p78*). I'm a bit of a UNIX/Linux veteran, having first booted Red Hat around 1995, and have used it in my personal and professional life ever since. Nevertheless, the article went into great depth and I came away learning a lot from it.

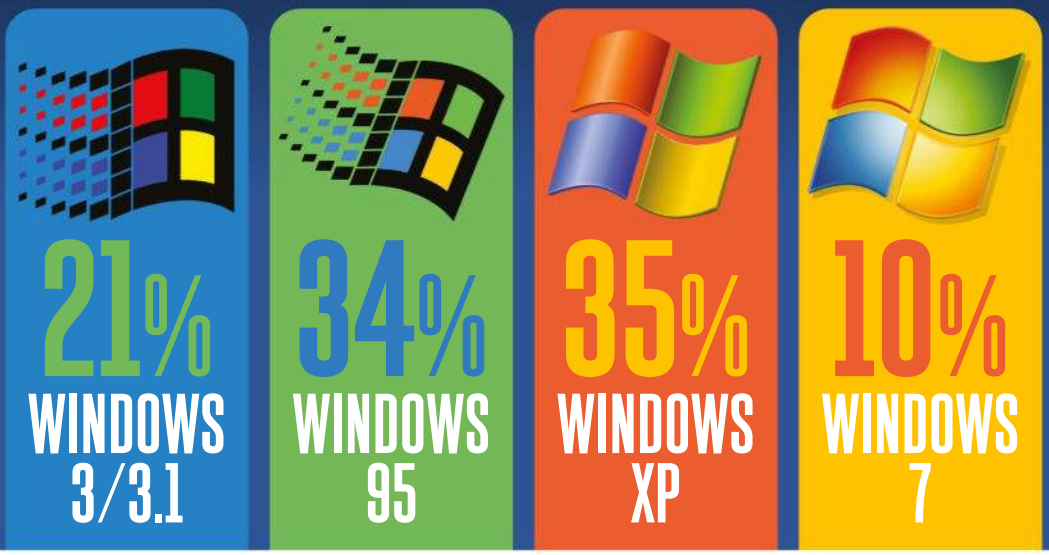
There were a couple of related things in the article that I thought could be expanded a bit more on in a future article. First, you have a paragraph which says "go partition your disk" when you're committed to installing a particular distro, but there's no mention how this might be done or the tools that exist to help. Bootloaders would be an obvious adjunct to that advice, too.

The other point was all the talk of thumb drives. It got me thinking that couldn't one simply install Linux on an external drive with a decent capacity – that is, like a thumb drive, only bigger. That's a bootloader question, I guess!
David Carter

Editor-in-chief Tim Danton responds: Thanks for these suggestions, David. You can indeed load Linux using a thumb drive (8GB capacity makes sense) and the point about partitioning may well be covered in our next Linux article!

Readers' poll

To tie in with the 30th anniversary of Windows 95, we ask: which release of Windows is the most important in history?



There was a curious split across our poll on X and Facebook, with XP the clear winner on the former but Windows 95 earning win after win on the latter. Backers included one of our much-missed writers, now retired, Paul Ockenden: "95, because I was part of the beta prog and used to enjoy having a UPS(*) dude bringing me new CDs a couple of times a week! (*) Brown van man, not uninterruptible power supply."

A view rapidly backed up by Dick Pountain. "Windows 95 [was the] most important commercially (finally worked well enough to kill DOS) but Windows 3.0 was more important historically – it worked just well enough to convince early adopters (inc. me) to try it in the face of real competitors like Gem and VisiOn or Amiga, or Atari." Lee Grant also got in the action by suggesting that Microsoft's most important Windows release was "the next one".

Jon Honeyball nominated NT4, a view shared by Pete Fletcher. "Gonna say NT4 – bringing the Windows 95 shell to the NT kernel laid the foundation for XP to push consumer computing forward in a meaningful way. I have a soft spot for XP and Windows 7, but we have NT4 to thank for them."

"XP had the biggest impact, most installs, longest lifespan and widest application and peripheral compatibility of any OS before or since I'll wager," wrote Mike (@Webbo_73) on X. A view shared by Michael Dear (@maxsendq). "It has to be XP, I don't think it was the most game changing or best (that was 7) but it was a solid and long running build."

Stuart Moore was one of many singing the praises of the Windows 3 generation. "Windows for Workgroups 3.11 with NetWare support was a turning point for the company I worked for as it finally became a viable option for a lot of our integration."

"Windows 3.1. It got us to switch from DOS. And did pretty much what 11 does for most users." David Crang

"Windows 3. Should have left good alone." Jan Swanton

"No-one going to nominate Windows 8? I'll get my coat..." Craig Franklin

"Windows 95. It gave us the Start button." Rajeev Arora

"Windows 95 was the groundbreaking one, but I reckon XP was the pinnacle." Sandor Kovacs

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30th ANNIVERSARY

The inside story of Windows 95

On its 30th anniversary, we retrace the development and inside stories of the operating system that changed the world

The history of Windows 95

Contributors: Simon Bisson, Barry Collins, Lee Grant, Jon Honeyball

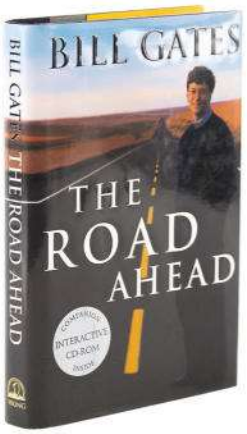
The Rolling Stones' "Start Me Up" blared across Microsoft's Redmond campus on the day Windows 95 was unveiled to the world. This was the big one. A landmark release on Microsoft's journey away from its DOS roots and into the 32-bit era. "Start me up and I'll never stop," shouted Mick Jagger, and so far that promise has held. Well, apart from the occasional blue screen of death.

It had been a long road to launch, twisting and turning away from its original vision with such vigour that even Mick must have looked on with admiration. But now it was here, bringing us the roots of the Windows user experience we still use 30 years later. Millions of copies were sold over the next few days, many to people who didn't even own PCs, with queues that reached around a thousand blocks. It even had a Special Edition release.

Windows 95 changed everything, not least the people who worked on its development, and the people whose careers depended on the PC. Here we look back on their stories, revealing insider tales of how Windows 95 was brought to market and the impact it had on the wider IT profession.

Crying out for change

The PC hardware of the early 1990s was nothing like the embarrassment of riches we enjoy today, where even sub-£1,000 systems are over-specified for most people's needs. The 80286 processor's limitations meant that memory was segmented, and we were still hamstrung by the old DOS 640KB limit. Third-party tools gave us access to more memory, but they had to be configured for each application, along with setting interrupts for ISA cards for sound and networking. Even for mice. Launcher applications used batch files to configure DOS and Windows for each PC setup.



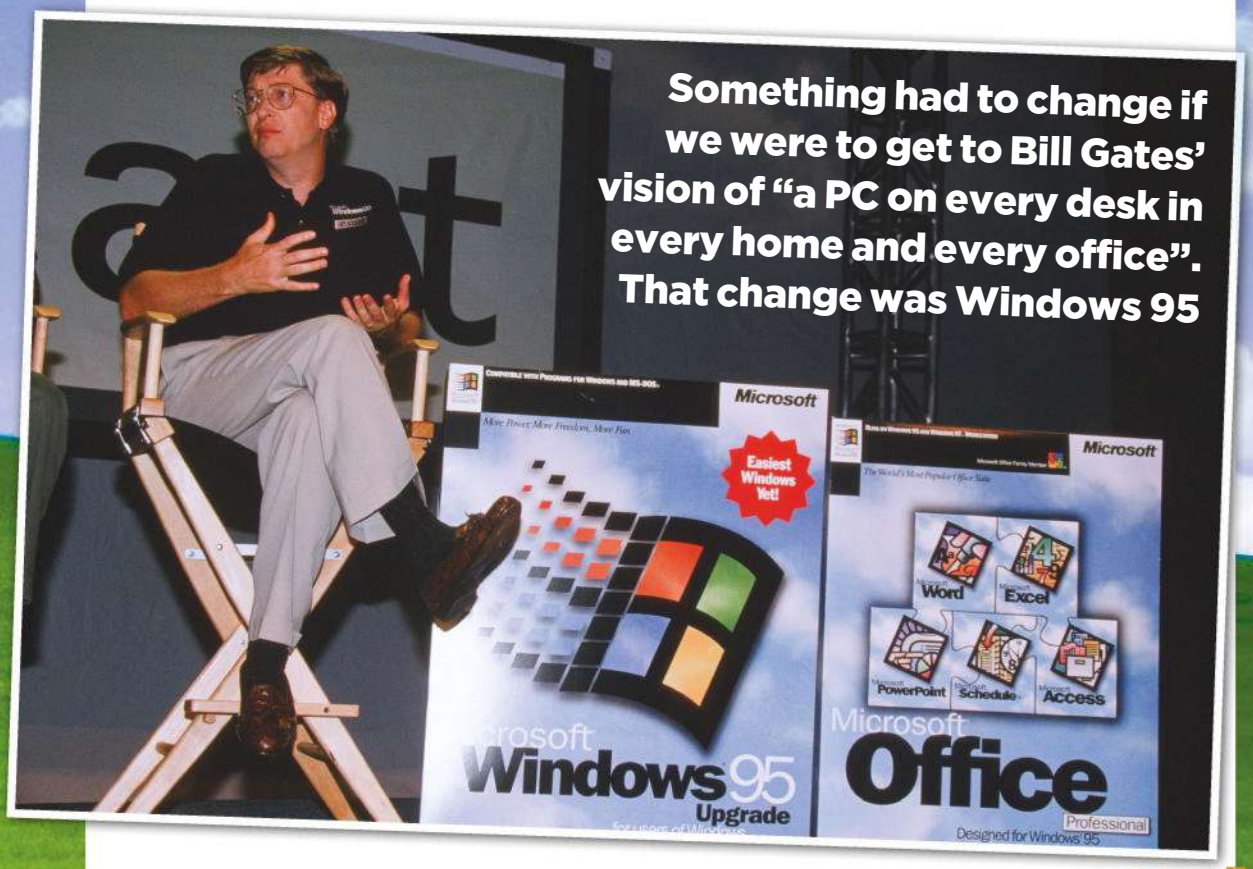
RIGHT Bill Gates laid out his vision for computing in his 1995 book *The Road Ahead*

Something had to change if we were to get to Bill Gates' vision of "a PC on every desk in every home and every office". That change was Windows 95.

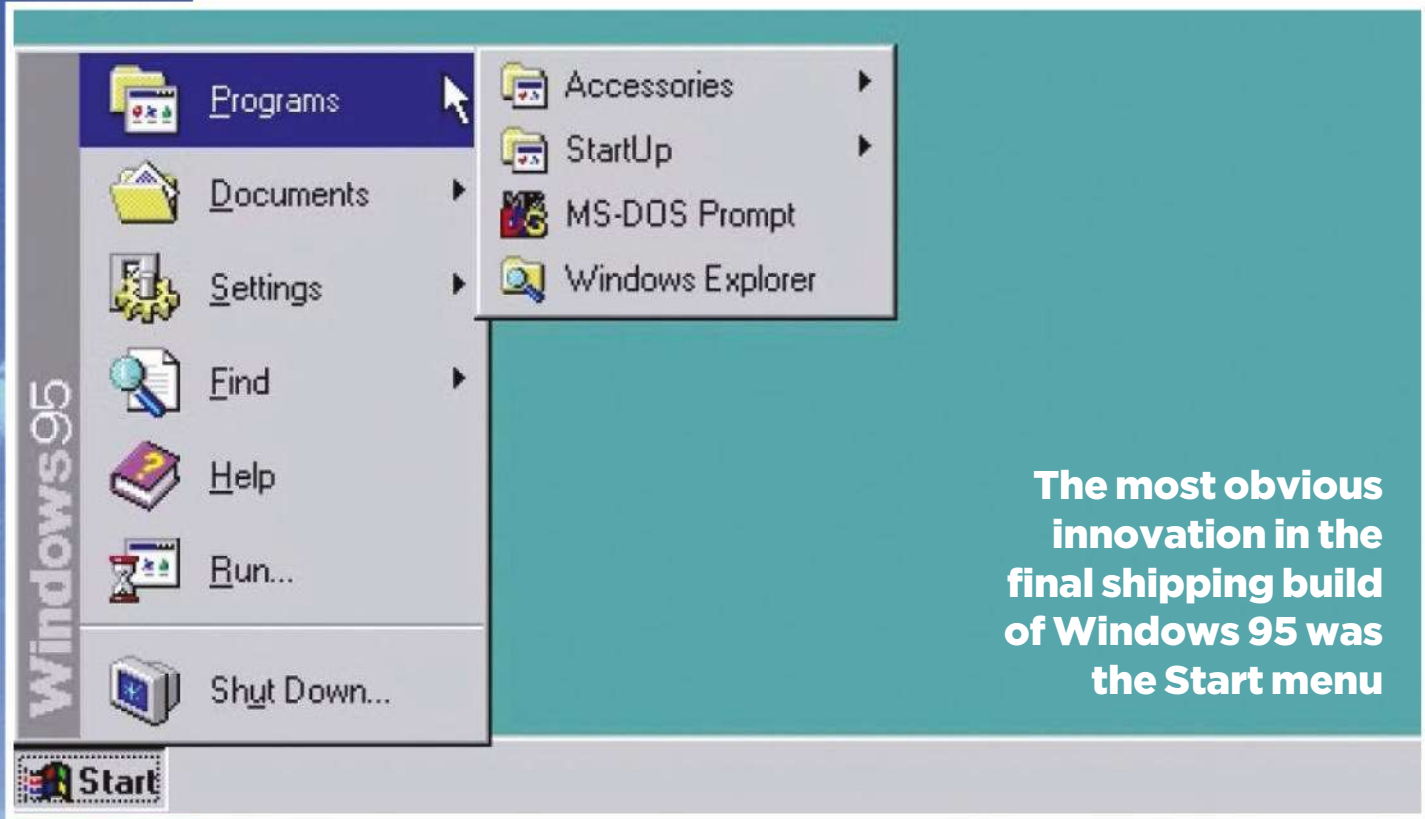
At the time Brad Silverberg was Microsoft's senior vice-president of what was the company's Personal Systems Division, running the project that would deliver Windows 95. Compared to today's Microsoft his team was tiny, but it delivered one of the company's most influential products. Silverberg has retired now, like many of his team, but when we recently spoke to him about Windows 95, he described the project as one with "lots of great memories".

Windows 3.1 had only just shipped when Microsoft began work on its successor. With Windows NT targeting the business market, the future was expected to be one with two different Windows releases: a consumer version carrying on the DOS heritage and a business OS building on NT. Codenamed Chicago and Cairo, the two new operating systems had a big vision of a connected home and work, one that was eventually captured in Bill Gates' 1995 book *The Road Ahead*.

The intention was to deliver an operating system that was ready for the next generation of Intel processors, the fifth-generation Pentium. This would



ABOVE **Gates at the launch of Windows 95, the operating system that changed everything**



The most obvious innovation in the final shipping build of Windows 95 was the Start menu

require a jump from 16-bit to 32-bit architectures, while still supporting existing 16-bit software.

It would also be a network-ready OS, with support for the rapidly growing TCP/IP networking standard alongside Microsoft's own workgroup software. Other innovations included DirectX, which Silverberg described as bringing "the most demanding and best games to the PC". *Doom* 95 would go on to become the first published DirectX game. Can it run *Doom*? Yes, it can. Although, somewhat ironically given its name, not until August 1996.

Start of something big

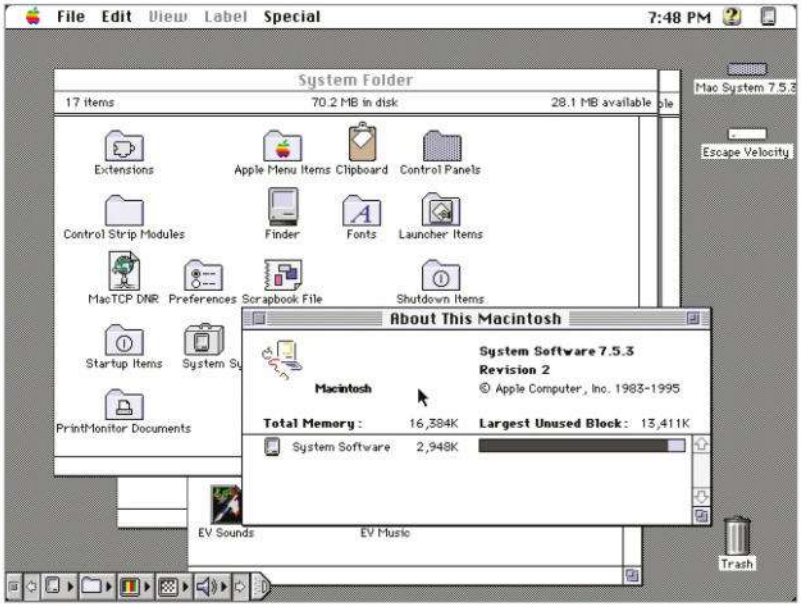
The most obvious innovation in the final shipping build of Windows 95 was the Start menu. Now a key element of the Windows user experience, Start was intended to avoid the Windows 3.1 problem of a crowded Program Manager, where it could be hard to find the applications and tools you wanted to use. With Windows 95's Start menu you could scroll through an alphabetical menu of applications, allowing you to quickly find what you wanted.

Early internal builds had both prototype Start menus alongside the then familiar Program Manager. Instead of one button, there were three, for system, search and help options. Those early builds were also only part of the way through the 16- to 32-bit transition, and many features were yet to be implemented. Looking back at those early builds it's possible to see that the evolution to Windows 95 was one that built on earlier Windows releases much more than the final release version showed.

By 1994 we started to see Microsoft dropping the Chicago codename in favour of Windows 95, and its final user interface starting to take shape. Delivering a fresh user experience was a key requirement for the new operating system. Windows 3.1 was tired, and it didn't compare well with Apple's Macintosh System 7. Microsoft set up a UI design team for Chicago late in 1992, early in Windows 95's development. It mixed designers, testers and programmers, with a development team dedicated to building out their designs.

The project had two conflicting design goals. It had to be easy for new users, but it also needed to support those who were already familiar with Windows. With these broad requirements, the team dropped Microsoft's traditional specification-driven process and opted for an iterative design approach, going from paper prototypes to code that was used in usability tests, both internal and with real-world users.

The system tray was an early part of the design, with user tests showing confusion with the early version of File Explorer, the File Cabinet and the folder-based Program folder. The team went back to the drawing board



RIGHT Apple's Macintosh System 7 was far superior to Windows 3.1

and looked at how people really used Windows 3.1, which showed serious flaws with the way Windows worked. That entailed a complete rethink, one part of which was a separate shell for beginners. That idea didn't pan out, but quickly became the foundation of the Start menu, intended to be a home base for users of all skill levels.

Users also found it hard to manage windows, losing track of them quickly and wasting time clicking to find what they were doing. The early Taskbar quickly gained what the team called "plates" that showed open windows, adding the option to click to bring them to the front or even hide them. New file dialogs made it easier to open and save files, a design that's still with us in Windows 11. Other tools made it easier to work with that perennial problem, the printer.

One of the tools used to help manage the design process, detailed in a paper by team member Kent Sullivan, was a bug-tracking database that helped the team identify different classes of issue and helped them focus on solving specific problems. It's a technique still used inside Microsoft today.

Win32 for the masses

Operating systems are more than a UI. At the core is their kernel, which manages low-level functionality. On top of that are the APIs and SDKs that let Microsoft, and developers, build applications. Windows 95 was one of those points in Windows' history where everything changed, with the transition to a new generation of silicon, and the programming interfaces needed to work with it – interfaces we're still using today.

The legacy of Windows 95 lives on in the shape of the Win32 APIs it inherited from Windows NT. Although much evolved since Windows 95, they're still the foundation of much of Windows development. Not all of Windows 95 was 32-bit, though, with some elements built as 16-bit applications. It also offered a feature that allowed older 16-bit applications to run alongside 32-bit code, ensuring backwards compatibility with older Windows releases.

That compatibility came at a cost: an engineer was sent to a large computer shop in Seattle and bought a copy of every PC program on their shelves. All the engineers on the project were assigned two applications and had to make sure they worked with every build, filing bug reports. After Windows 95 shipped they were allowed to keep their adopted application, which left some engineers with quite unusual boxes in their offices.

The team went back to the drawing board and looked at how people really used Windows 3.1, which showed serious flaws with the way Windows worked

The project did much to overturn the image Microsoft had at the time of delivering buggy, unstable code. Veteran Microsoft developer Raymond Chen tells the story of a Windows 95 developer who went to an Apple event wearing a project T-shirt and had a conversation with an Apple engineer who'd been looking at the beta code. "I have to commend you guys on Windows 95 so far," the engineer said. "It sucks less."

There was a lot of focus on the little things, such as Brian Eno's startup sound. In later interviews he compared it to a tiny jewel, and noted that after composing it, a traditional three-minute track seemed like an ocean of time.

Windows 95's border issues

Image: ??????????

Former Microsoft vice president Laura Butler tells *PC Pro* how a pixel almost broke Windows 95

Few people realise just how many problems were caused by making the border around windows in Windows 95 one pixel bigger on each side to create a bevel effect.

We had system metrics, a way for apps to get and use the values of things such as colours, border sizes and so on at runtime. We had functions that would compute how big your window should be given a certain display area, if you wanted a title bar and menu bar and so on. We had functions to convert screen coordinates to window frame and window client coordinates. But did developers use them properly? Of course not!

Every which way developers could get it wrong they did. We're talking developers at big famous software companies. They hard-coded "1" values for border size. They did crazy magical calculations, ending up with windows that were too big or too small and extended off screen. They had off-by-one errors with painting, and off-by-one errors with mouse interactions. They had divide-by-zero errors.

Apps crashed in every which way an app could crash. Even some services with invisible windows had problems. Best of all, app-crash-handling code often crashed too because it had never been tested before. Pizza Hut and Starbucks made a lot of money in 1994 and 1995 because of that blasted bevel.

LEFT Millions of copies of Windows 95 were snapped up by eager users

Clinging on to DOS

As much as Windows 95 tried to show that it was a system in its own right, like earlier Windows versions DOS was still there. As it boots, however, the underlying MS-DOS 7 system becomes less important, with Windows functions replacing most of its capabilities, relegating it to another compatibility layer, this time for DOS drivers. This approach caused Microsoft legal issues down the line, as it locked out third-party DOS systems which had been able to work with Windows 3.1.

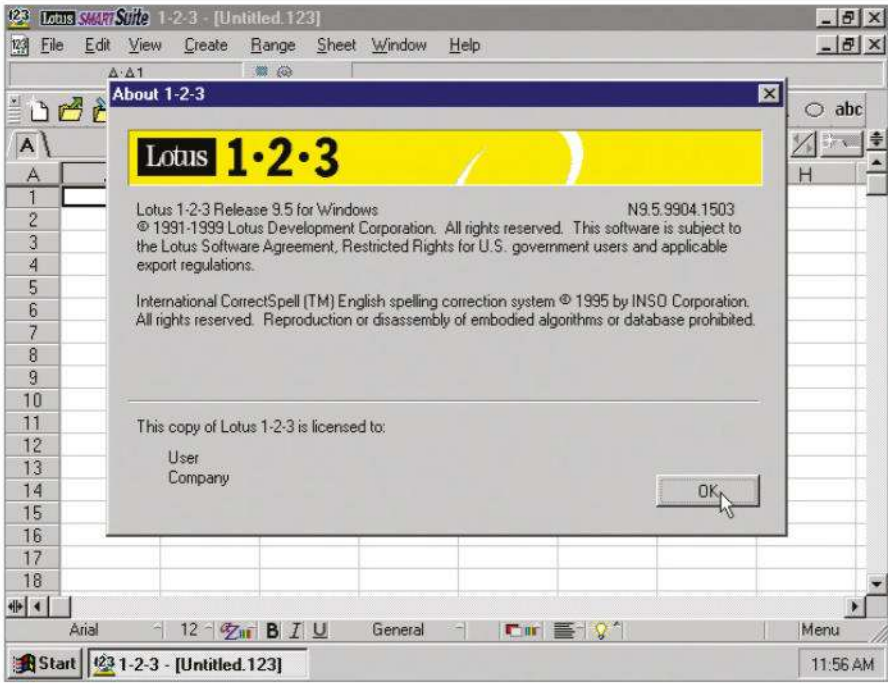
Microsoft had shipped a 32-bit operating system in the shape of Windows NT, but that was a green-field site, with no real ambitions for backwards compatibility. Windows 95 was different, as it would allow your DOS programs and your Windows 3.1 applications to run alongside newer 32-bit Windows 95 applications. Windows was intended to be backwards compatible, and that would require plenty of work. It would also require a lot of hacks and shims to work around the inevitable issues.

BELOW Gates' plans for an object file system in Win95 failed to materialise

Windows NT had introduced a set of 32-bit APIs, in the shape of Win32. It's been a surprisingly long-lived set of technologies that have evolved with Windows editions, into the .NET world and outliving technologies that were expected to replace it, such as WinRT and the Universal Windows Platform. The early Win32 spun off a mostly forgotten extension to Windows 3.1, called Win32s. This allowed 32-bit applications to run in the 16-bit Windows environment, with a subset of the Win32 APIs (hence the "s" in its name).

Win32s introduced the concept of "thunking" to run inside the constraints of Windows 3.1, especially in its shared address space. This is a risky technique, as it makes it hard to manage memory and protect the operating system kernel. Badly written applications would crash Windows.

In Windows 95, 16-bit applications used the same technique, thunking into the larger 32-bit memory space. This had the side effect of making code safer, as it was much harder for memory allocations to collide. There also needed to be a lot of hand-coded shims that took the idiosyncrasies of DOS and early Windows code and handled OS calls, redirecting them to new features and functions. The resulting legacy of backwards compatibility has remained to this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ABOVE Windows 95 was designed to be backwards compatible, so that classic DOS programs such as Lotus 1-2-3 still worked

The time zone snafu that sunk Poland

Image: Microsoft/Raymond Chen

Speaking on the Dave's Garage YouTube channel, Microsoft veteran Raymond Chen recalled an awkward problem with the Windows 95 clock

Windows 95 introduced the time zone map. Instead of selecting your time zone from a drop-down menu or some such, you clicked on a map to identify your current location. "Everybody thought that was a lot of fun," said Chen. "Until geopolitics entered the picture."

Microsoft used official UN-recognised maps to determine boundaries, Chen said, but not every country recognises those maps and there were all sorts of border disputes around the world. "A small European country would contact us and say 'our country's kinda small, can you give us one of our neighbour's pixels to make it easier to click on, because our citizens are having difficulty clicking on that thing because we have to hit a really tiny target," Chen recalled. Of course, that would prompt the shrunken country to get in touch, saying "hey, why did you give our pixels to our neighbour? If you look at the map, that pixel belongs to us!"

Microsoft eventually decided to ditch drawing borders between countries. But that introduced a very unfortunate bug that basically eradicated Poland. Microsoft had ditched a colour-coding scheme to highlight countries in a particular time zone, fading out any country not in that zone. But when Poland's time zone was changed in the 1990s, the colour coding wasn't updated properly, meaning on the world map "there was ocean where Poland was meant to be".

"I forget exactly when we finally fixed it," said Chen. "But there was a period of time where if you went to the time zone map, instead of Poland you saw what we called the Great Polish Sea."

One of Brad Silverberg's goals was to make it "easy for users to add new devices to their PCs"

day, with Windows still shimming old code – and with classic DOS programs such as Lotus 1-2-3 still running.

Bringing Win32 to consumer Windows was a big move. Not only did it set the wheels in motion for the Windows XP-era merger with Windows NT, it began to reduce the risk of memory being used by more than one program, introducing protected memory allocations that could be any size. No longer was memory allocated in 64KB segments, and an error in one program was unlikely to affect other code – unless it was running in one of the shared memory spaces that were still needed for compatibility.

Having a common API for Windows 95 and Windows NT meant that programs written for one should run on the other, though there were issues with Windows 95 thunking back down into 16-bit sections of the kernel that hadn't been rewritten as 32-bit code. A complete rewrite would have to wait until Windows XP, as it was considered too big a task to complete in one go.

As much as we like to think of Windows 95 as an elegant new operating system, it was really a loosely connected set of features that happened to work, with much more of Windows 3.1 and DOS under the hood than we remember. One example of just how loosely connected Windows 95 was? Its installer, which was built around three different operating systems: first a version of DOS, then a minimal version of Windows 3.1, and finally Windows 95 itself. This actually made sense, as it addressed the various installation scenarios: installing on a fresh system, or upgrading from Windows 3.1 or an earlier Windows 95 release.

Another change was support for what came to be known as "plug and play" hardware, where the PC BIOS set up resources at boot, managing address, interrupts and direct memory access. One of Brad Silverberg's goals was to make it "easy for users to add new devices to their PCs".

As part of Windows 95's development, Microsoft delivered a set of standards that were intended to allow new hardware to work without tedious manual configuration, though in the early days incompatible older hardware led to conflicts and the nickname "plug and pray" when things inevitably failed to work. It would take time for the hardware industry to deliver on this promise, but once it did, we quickly forgot how awkward working with hardware used to be.

How we tested Windows 95

Jon Honeyball fondly recalls testing early builds of Windows 95

Back in the 1990s, testing operating systems when they were in beta release was fun. The fun wasn't the crashes, the reinstalls or the piles of 3.5in floppy disks you had to pump into your computer. It was seeing the rapid rate of change on every new build. We were watching evolution in action.

In the mid-1990s, Windows NT was carving out its high-end powerhouse niche. But the requirements were still too high for many mainstream customers, who wanted to move on from the relatively lightweight Windows 3.x. Hence Windows 95 was born, as a stepping stone that would eventually lead to the merging into Windows XP of both the NT and 9X worlds.

Beta testing for Windows 95 was on a CompuServe group, and even the most senior members of the team were present, keeping a watchful eye over the bug reports. I made friends with them, and regularly chatted to Brad Silverberg, the head of the Windows 95 team. My most memorable bug was finding that the Windows Calculator app couldn't do sums properly: 2.11-2.01 = 0.00 was a particular clanger.

But back then life was simpler, the beta testing groups were smaller, and it felt worthwhile to make the effort. After all, only a few years previously we were still using Windows 2.x, and that was extremely primitive by comparison with 95.

Today, it's almost stagnation, beta testing isn't really serious any more, and there's no sense of being in a team. So I remember Windows 95 very fondly indeed. Not so much for the product itself – I was a fervent Windows NT flag waver. But for what it meant at a critical time in the evolution of the PC.

Maybe I could find such fun in the open-source Linux world today, but I highly doubt it. Nobody seems to be doing radical OS and user experience work any more. Except for Apple's Vision Pro, of course.

The big omission

Not everything that was planned for Microsoft's mid-90s operating systems made it out the lab. The most obvious was the most ambitious, the object file system.

Bill Gates' big vision for the Cairo and Chicago projects was the object file system. Fascinated by the then new concept of object-oriented computing, he envisioned treating

LEFT "Plug and play" support made it easier to connect hardware

Microsoft
Microsoft® Windows® 95 Preview Program
Disk 1 - Setup
Windows Series
Disk format: High-density (DMF)
Setup Instructions:
1. Start Microsoft Windows.
2. Insert Disk 1 - Setup in drive A.
3. From Program Manager, select File menu and choose Run.
4. Type a:\setup and press ENTER.
Disk Assy 050-031-801
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RIGHT The Preview Program made the beta version of the OS available to all

files as objects, making them easier both to search and to use in your applications. Aspects of the object file system appeared in Office's OLE tools, but the system was never to ship. Prototypes proved too unwieldy and too slow, and used too much memory and disk space, even for the new hardware Microsoft was expecting to arrive alongside Chicago.

The object file system never appeared in any public builds of Chicago and ended up as part of the business-focused Cairo concept (which would end up being cancelled, and shipping as parts of the Windows NT 4.0 release).

ABOVE Punters queued for hours to get hold of Windows 95

Object file systems have remained an unattainable part of the Windows vision, reappearing as WinFS as part of the abortive Longhorn project. Microsoft's ambition of delivering an object file system never went away, despite high-profile failures, and they're still being experimented with: the semantic search that underlies the Recall tool designed for Copilot+ PCs owes much to the metadata models in the object file system and WinFS, though now built by AI rather than humans.

Testing times

Once Microsoft had nailed down what was going to ship with Windows 95, it made the surprising decision to offer users a public beta release, called the Windows 95 Preview Program. There was no practical means of delivering downloadable software in those days, so this came as a stack of floppy disks that could be used to install a clean version or upgrade from an existing Windows 3.1 install. This was a paid program, with a subscription costing £19.95. The preview version was designed to time out in November 1995, by when the final version would be widely available.

There was no practical means of delivering downloadable software in those days, so the Preview Program came as a stack of floppy disks

It wasn't anything like today's Windows Insider program. For one thing there was no online bug reporting, though you could report issues through the included trial of the Microsoft Network (more on which below). Looking back, the Preview Program wasn't really what we now think of as a beta. The code was almost finished and relatively bug free. It was more of a marketing tool, to get people excited about what was a very big change, and to get them ready to move away from the still quite capable Windows 3.1. It certainly worked, with the launch resulting in queues at computer stores around the world.

There was still one big thing missing in that first launch: the internet. Yes, Windows 95 had support for workgroup office networking out of the box, and you could bundle together a mix of free software and shareware to put your PC online, but Microsoft wanted you in its own walled garden. It had seen how successful AOL and CompuServe were, offering subscriptions to their online services, full of content. That's why it had been working on a project codenamed Blackbird, an online service of its own. Like AOL, the new Microsoft Network was a subscription service – but it was one that turned out to be very short lived, as an explosion of ISPs changed the way we went online.

Microsoft was going to have to quickly launch add-ons, in the

Put that in your 3D pipes

Writing on Microsoft's The Old New Thing blog, company veteran Raymond Chen recalls a screensaver complaint

Although not built specifically for Windows 95, the 3D pipes screensaver will be fondly remembered by users of the operating system. Well, not so fondly by some, it seems.

"A customer complained that they were losing productivity because employees were spending too much time running the 3D Pipes screensaver and waiting for teapots to appear," wrote Chen. "They requested an option to increase the likelihood of a teapot, so the employees would be placated more quickly and get back to their work."

Teapots were an Easter Egg in the screensaver, appearing in the join of pipes in tribute to the Utah teapot, a standard reference object in the computer graphics industry.

"I can't find any evidence that this feature request was accepted," wrote Chen. And, "despite rumours to the contrary, the rate of teapot appearance does not improve the longer you leave the screensaver running". Get back to work, slackers.

shape of "Plus!" packs, that brought its own browser and dial-up tools to Windows 95. The combined browser and dialler in Plus were called the Internet Jumpstart Kit, with a browser based on Spyglass Mosaic, Internet Explorer 1.0. It would be the only Microsoft browser that wasn't bundled with an operating system release, as Internet Explorer 2 came as part of the OSR 1 refresh. The initial deal with Spyglass resulted in legal action; Microsoft avoided paying royalties for the use of the browser by making it a "free" component, though it ended up paying more than $8 million in a settlement.

The first releases of Internet Explorer were basic, just enough to make sure that Microsoft had skin in the game. But it was the later release of Internet Explorer 3 that made the difference, giving Windows 95 the online market share Microsoft craved.

Hacked together miracle

Looking back at Windows 95, it's clear how hacky its development really was. Beneath that shiny, customisable user experience, the transition to 32-bit operation was not a smooth one, nor was the introduction of a whole new way to work with PC hardware. Windows 95 had to do a lot of heavy lifting with very few resources.

There's one other aspect of the project that made it influential, one that we tend not to think about 30 years on. It's the part Brad Silverberg is perhaps most proud of. "It was built as a worldwide product from the start and dramatically expanded the universe of people who used PCs," he said.

He passed on a quote he found on LinkedIn from someone who was a child in India in the 1990s (and who went on to work for Microsoft). "Windows 95 was my first introduction to the magic of PC computing. I loved everything about it. As a kid in India it helped bring the internet to me."

It wasn't only kids who were getting their first taste of computing via Windows 95, but elders, too. "It meant my mom could finally be able to use a PC – to play bridge online, read the news, stay in touch with family and friends," said Silverberg.

That universal appeal made it an operating system like no other before it, and its influence is still felt today, from the way software manages hardware, to how we build and use software, to the magazine you're holding in your hands. That's quite the legacy, and one its relatively small team of developers and designers can still be proud of.

And that launch Special Edition we mentioned at the top? It was the same version that we all used, but with different printing on the box.

Windows 95: The repairer's perspective

PC Pro's Lee Grant reflects on a back-breaking era for PC repairers

Windows 95 was peak "beige box" era in PC land. Our repair shop floor was stacked with a myriad of bland towers which, because of their thick steel chassis, weighed the same as a small family hatchback. One frequent visitor to our shop had casters and required two people to lift it. Laptops weren't much better but were rarely seen.

Building Windows 95 desktops presented physical complexities: 40-pin IDE drives used 40mm wide cables and, although they could be rolled, they remained unwieldy. If a customer wanted twin opticals, dual hard disks, a ZIP and floppy, it wasn't the work of a moment to connect everything together. Plus, that rat's nest of data and power lines provided airflow problems in an era before case manufacturers considered cable management.

And that was just the start. Even a fundamental task such as installing a CPU required the correct alignment of jumpers to ensure the front side bus was up to speed. Getting drivers into a Win95 machine wasn't simple as floppy disks were usually corrupt and USB support was flakey. Many manufacturers didn't have websites, so driver repositories such as driver-downloads.com were vital in preventing most 95 users from staring at a 640 x 480, 256-colour output.

Windows 95 had two neat tricks to aid repair. Step-by-step confirmation could be invoked via F8 during boot. From this, each line of MSDOS.SYS and AUTOEXEC.BAT could be loaded or ignored to help find faults. Mashing F5 during the boot sequence would also start the machine in Safe Mode, a much simpler method than exists today.

Some Windows 95 fixes were beautifully simplistic. To repair a machine that wouldn't boot, I inserted an MS-DOS system disk to start the machine and typed SYS C:. This DOS command copied IO.SYS, MSDOS.SYS and COMMAND.COM from the floppy to the C: root, allowing the machine to start.

Windows 95 lacked the polished user-friendliness of its successors, but it didn't give a stuff about what you did to it. I remember using Windows 95 for the first time and enjoying the improvement over Windows 3.1. Later, I thought the same when Windows 98 arrived to take Microsoft's vision further. The one thing I missed was the eight orange words on shutdown: "It's now safe to turn off your computer."

LEFT Windows 95 helped to open up computing for the masses

BIG TECH

Many tech firms demand their staff work long hours. Barry Collins examines the toll it's taking on employee wellbeing

Sixty hours a week "is the sweet spot of productivity", according to a recent leaked memo written by Google co-founder Sergey Brin. Sixty hours? Man up, Sergey. The Infosys co-founder Narayana Murthy called for young staff to work 70-hour weeks, claiming "I don't believe in work-life balance".

Seventy hours a week is dialling it in, according to Alibaba founder Jack Ma, a big fan of China's "996" work culture, which entails working from 9am to 9pm six days a week. "If you find something you like, there is no such thing as 996; if you don't like it or don't love it, going to work is torture every minute," he stated in a 2019 blog post, translated from Chinese. (*See "What's it like to work 996?" on p37.*)

Even if you absolutely love your job, there's no shortage of evidence that working all the hours the big tech bosses demand *is* akin to torture – damaging to your physical wellbeing, as well as your mental health. In March, a survey from ISACA, a global professional association, found that 61% of IT staff said that a heavy workload was contributing to their high levels of workplace stress and burnout, while more than 40% said tight deadlines (44%) and long hours (42%) were impacting their wellbeing.

For all the free healthcare, gym memberships and six-figure salaries big tech companies offer, is signing up for one of their demanding jobs in effect writing off your own wellbeing?

Killing yourself at your desk

There's no shortage of evidence that working the long hours many of the big tech firms demand is detrimental to your health. It might not be sending miners down a coal pit, but the effects on employees' health can be every bit as serious.

A 2021 analysis conducted by the World Health Organization and the International Labor Organization showed a clear link between long hours and life-limiting conditions. The study showed that working 55 or more hours per week – far less than the figures being demanded by the big tech bosses – is associated with a 17% higher risk of ischemic heart disease and a 35% higher risk of stroke compared to those working standard 35 to 40-hour weeks.

To put that into hard numbers, in 2016 an estimated 745,194 deaths and 23.3 million disability-adjusted life years were attributed to long working hours. Three-quarters of a million people dying because they spend too long at work. To put this into context, that's roughly half the number of people who died of Covid in 2020, before vaccines were introduced.

Even if long hours don't take a physical toll on you, they could have a mental impact. A 2017 study by the Society of Occupational Medicine found that people who worked over 48 hours per week – again much less than Brin, Murthy and Ma were

BELOW Sergey Brin, Narayana Murthy and Jack Ma are all in favour of longer working hours – despite the damaging evidence

suggesting – had "significantly more depressive and anxiety symptoms and worse sleep quality" than those who were working beneath that threshold.

"We know that if you're working a lot of long hours, you need sleep to recuperate," said Dr John Blythe, director of cyber psychology at security firm Immersive, who's had almost 15 years of experience working as a behavioural scientist. "It's a negative cycle of overworked, burnout, poor-sleep outcomes, and ultimately tends to lead to people leaving the organisation."

That mental toll also leaves employees unable to do their jobs to the best of their ability, as Caz Brett, senior director of product management at work management platform Smartsheet explains. "There's a certain drop-off point where we are no longer productive," she said. "That's why there are so many shelves in Waterstones filled with self-help books that are all helping people with productivity. The studies say that productivity massively declines after 50 hours.

"There is no added benefit for working beyond 50-55 hours."

Why do firms do it?

The obvious next question, then, is: why? If there's such overwhelming evidence that working long hours batters employees' health and that it harms their productivity, why do so many companies do it? Big tech firms such as Google are surely monitoring the output of their employees. If those staff were really unable to perform after working 60 or more hours a week, wouldn't they stop them?

There's a certain drop-off point where we are no longer productive. There is no benefit for working beyond 50-55 hours

"I think... it comes down to how they respect their employees," said Dr Blythe. "If they care about their talent management and maintaining their top performers, they would invest a lot in employee wellbeing.

"They focus mainly on their bottom line," he added. "Perhaps that's why they're driven more towards 'if you work hard, if you work longer hours, then we're going to get more out of it', which isn't supported by the 40 years of research that shows the negative impact of overwork."

The top-down culture driven by the leaders of the big tech firms is another big determiner of employee behaviour, according to Paul Sephton, head of brand communications at office equipment maker, Jabra, which recently published a report on how AI will change workplaces.

"The founder mentality drives very high expectations," he said, referencing the call for 60-hour work weeks from Google's Sergey Brin. "It's a high-purpose sector and there's a large belief attached with that, that to drive the change required you need people who have that sense of purpose, and that if you're recruiting those people, they probably want to stay for those longer hours."

Dr Blythe agrees. "It often comes top down, so leadership doing those behaviours themselves and promoting it," he said. "It creates that cycle of long, long working hours culture and people seeing that as the way to be a top performer in the business."

The meetings tax

Some of the need for long hours boils down to the sheer bureaucracy of working inside big firms, Caz Brett believes. "I think it all comes back to inefficiencies in how we work, in the processes that we set up, in the tools that we use," she said.

Too much time is wasted in companies waiting for "a meeting to happen before you can make a decision on something," she said, "whereas if you could make the decision async and then move things forwards, you don't have to spend that time in the waiting zone".

Since Covid, the volume of meetings has "gone up in the order of 300%" according to Jabra's Paul Sephton, which results in employees spending longer at their desks. "There's definitely a culture shift from things we might have been able to do just with corridor moments, seeing people in the office briefly and having a five-minute catch-up is now maybe turned into a 15-minute meeting," he said. "I think coming out of Covid, everybody got into this habit of booking 30 minutes or 60 minutes instead of being able to get that face time."

Sephton says his company is trying to "drive a strong culture of just being able to call people ad hoc or set up shorter meetings, rather than booking time," to prevent workdays being bogged down with meetings. But if bosses are reading this and thinking it justifies a mandate to return to the office, Sephton disagrees, arguing it's more about empowering employees with a greater degree of autonomy. He said people are increasingly looking for an employer that says: "'I trust you to get your job done no matter where you're doing it from', and then employees are respecting that trust and almost putting more in as a result of it."

The jobs that have made me come alive, where I've achieved miracles? I've happily worked hundred-plus-hour weeks

And because it's 2025 and we can't write this many words without mentioning AI at least twice, Caz Brett thinks it could be the key to reducing some of that meetings fatigue. "Lots of people are a little reluctant to lean into AI and... I understand some of the fear there, but it's such a helpful tool for people to be able to automate and essentially free themselves up to do some of the strategic thinking or some of the intentional meetings," she said.

If you can use AI tools to summarise meetings in which you're not required as an active participant, "the meetings that you do have become even more important and more intentional," she said. "You're not drowning in them."

ABOVE Office workers are spending far more time in meetings than before

Even if employees can free up more time from meetings to focus on their job, that won't stop companies from clock watching. But Brett argues that measuring the time people spend at their desks is a false metric in the first place. "I think there's a focus on the wrong measurement," she said. "Fundamentally, I think we should be focused on how we achieve the best outcomes.

"If you feel connected and valued, and you feel that you understand the outcomes, that will then help you drive those forwards. If all you do is go into an office every day and you're working for, let's say, 12 hours, but most of it is just spent staring at a screen or on a call, are you really getting any added benefit in that moment? Probably not."

Stockholm syndrome?

Nobody wants to be working all the hours [enter your deity of choice here] sends, do they? Well... it seems some people rather like it. When I put out a call on social media, asking if anyone had experience of quitting an IT job because of the long hours, the only two people who responded were *PC Pro* readers who said the opposite was true – that they'd walked away from jobs with regular hours because they didn't find them challenging.

"I've realised that the really soul-crushing jobs, the ones I've had

to grit my teeth and batter on through because we have a mortgage to pay, have all been the 9-5, Monday-to-Friday jobs," said one reader, who asked to remain anonymous.

"The jobs that have made me come alive, where I've achieved miracles, where I've felt I was really contributing to pushing the industry forward? Those, I've happily worked hundred-plus-hour weeks, often seven days a week, for no additional reward beyond the base salary."

Even age (he's now nearing the end of his career) hasn't withered his appetite for such jobs. "Various psychologists have written about Flow State, where a person gets into a state of creativity where the outside world shrinks and disappears, and the whole focus is on the project. I've had jobs where that is the default state for 12 months at a time, and I would kill for another one of them today," he said.

However, a little self-reflection does creep in. "Now that I've written this out, though, I'm not sure how much of that was due to the early state of the IT industry, where we were all learning as we went, before programming became a science. And some of it might simply be the enthusiasm of youth, I don't know."

That reader's attitude is similar to that of my second respondent, who also asked to remain anonymous. "When I go for an interview for a job, and if they throw at me there's on-call [duties], there's potentially times when you're going to need to work out of hours, anti-social hours, my answer is usually – and I don't just say this to come across well in the interview, but it's what I genuinely feel – if that's the job I'm in," he said. "If it's needed, it needs to be done. So, yes, that's a trade-off that I'm willing to accept. I'd rather do that and be active than be not used to my best capacity."

Is there a degree of Stockholm Syndrome at play here? The victim sympathising with their abuser? Dr Blythe says research shows that employees are more willing to run through brick walls for their employers if they're otherwise treated well. "What the research does support is that if you have high job resources – which are things like good line management, autonomy over your work, social support in the workplace – those positive aspects of your job buffer the impact of the job demands," he said.

There's also the salary, of course. Many IT jobs are well paid. Do staff feel they owe it to their employer to work long hours as a result? "I certainly think people will rationalise it, particularly at that economic level," said Dr Blythe. "But if that leads to burnout... that's when it becomes problematic, because it's having that impact on psychological and physical wellbeing."

It's also worth noting that the two readers I spoke to who thrived under long hours are men. The long-hours culture "disproportionately harms women, and that can lead to more burnout," said Caz Brett. "It can lead to reduced diversity and leadership."

Brett said research shows that diversity at board level benefits businesses, "so what we can do to encourage flexibility and to encourage outcomes, rather than just focusing on hours, will lead to better business outcomes".

Changing culture

Ultimately, however, it's not only employees who follow their leaders, but businesses. If hugely successful and hugely profitable companies such as Alibaba, Google, Infosys and many others demand long hours from their staff, others are likely to follow. And it's not as if it's a new phenomenon. Bill Gates regularly told stories of pulling all-nighters in the early days of Microsoft to meet deadlines or to get the edge on competitors.

Caz Brett argues it's misleading to suggest that the big players always set the example, though. "I feel like some of the loud voices of 'we must work long hours', your example of Google, I don't think that is representative," she said. "I know that because we see more people using platforms like Smartsheet, collaborative work management platforms to be able to leverage and support their work, to move to more async models.

"The tech industry has a much stronger sense of key performance indicators and company goals, and there's definitely an increased focus on outcomes," she added.

And some of those old workaholics have revised their opinions on toiling around the clock. "Back in my early Microsoft days, I routinely pulled all-nighters when we had to deliver a piece of software," Gates said in 2019. "I even stayed up two nights in a row on occasion – I don't recommend that. This book [Matthew Walker's *Why We Sleep*] taught me a lot about the importance of a better night's sleep."

What's it like to work 996?

Working from 9am-9pm six days a week might be the Alibaba founder's idea of a good time, but it's not Jack Forsdike's. He moved to China in 2022, keen to take advantage of his Chinese and Spanish degree. He joined games developer NetEase, first working on game localisation, before moving on to a marketing role and then into game design itself. He lasted just over six months in that last role, because the demanding hours pushed him to physical burnout.

"As things started to get busier and busier for us, we had quite a big beta test coming up, so we were really crunching towards that milestone," said Jack. "And it was the month-and-a-half before that [deadline] that the hours started to get really crazy – 70-hour, 80-hour weeks.

"There were some times where, after working six days, I would come in again on Sunday, just because I knew that with the workload that I had, the game simply wasn't going to be ready for beta, and my part wasn't going to be finished."

This wasn't people volunteering to work crazy hours for the sake of the project; it was mandated hours. "You are told you need to be in the office from 10am to 10pm Monday to Friday, and then 10am to 6pm on Saturday," Jack said.

That made NetEase a pretty depressing place to work. "It affects morale," said Jack. "Nobody wants to be working those hours.

"I think a lot of people were just resigned to the fact that if they want to work in the games industry and follow their passion in this sense, then this is probably something they need to accept. Because unfortunately, that almost is the reality in China, that the games industry is generally known for having incredibly long hours, and NetEase is already quite a big name within the industry."

Jack didn't find the mental fatigue of working those long hours difficult. "Mentally, honestly, I was probably actually fine, because I was really enjoying the work I was doing," he admitted.

However, the lifestyle took a physical toll. "Looking after your health is something that takes time. You need to be coming home on time and cooking yourself a healthy meal. You need to have time to go and work out, go to the gym or go for a run. I used to play tennis a couple of times a week; that completely disappeared once I started working those long hours.

"My health definitely declined," he added. "I got less and less fit, and I put on weight because I was just coming home and eating junk food. Or, even worse, the company was ordering a bunch of junk food in for everyone to get them through the late nights. You know, McDonald's ordered at 9pm or 10pm or on the Saturday afternoon."

In the end, Jack left the company, although not China itself, where he and his partner are considering a career in media creation. A career that, hopefully, demands fewer late nights than the games industry.

WHICH HOME VOIP SERVICE IS BEST FOR YOU?

As Skype closes down and residential landlines switch to internet services, Nik Rawlinson picks the best VoIP providers for staying connected

There's nothing new about VoIP – or, to give it its full name, voice-over IP telephony. Even before the Covid-19 lockdown, millions of people were using services such as Zoom, Teams and Google Meet for live audio and video conversations over the internet. And when half the nation was obliged to work from home, they quickly became household names.

Yet the service that was once the biggest of all is on its way out. Microsoft bought the enormous Skype platform in 2011, but six years later it started to phase it out in favour of its home-grown Teams product. And in February of this year, Microsoft announced that Skype would be shutting down on 5 May, replaced for both business and home users by the Teams service that's now been integrated into Windows 11.

For many people, this will be a non-event, as Teams can do most of the same things as Skype. However, the one thing it doesn't have is the Skype Number feature (previously known as SkypeIn), which allowed people to call your Skype account from any mobile or landline. The Microsoft Support website blankly states that "Existing calling and Skype Number subscriptions will continue to automatically renew until April 3, 2025 and will then remain active until the end of your active subscription period". After that, your number will expire. While Teams does offer a similar phone service, this is only available on business plans; home users are limited to making internet voice and video calls to other Teams users.

Frustratingly, Skype is closing down at a time when it should be flying high, since the UK is in the midst of a complete switchover from the traditional phone network to VoIP. The transition itself should be good news, as it means you no longer need to pay line rental just to get an internet connection. It also means that anyone who still wants a landline is no longer tied to their chosen broadband provider, and can source a line from wherever they want. Since VoIP lines aren't tied to a geographical exchange, you don't even need to use a number from your own local area or country. When you move house, you can take your number with you – and in many cases you can make and pick up calls on your mobile using a VoIP app, making your "fixed" line just as flexible as your cell number.

In short, everything that made Skype so popular is still available; you just need to move to a commercial VoIP service. There are plenty to choose from, so the question is: which is right for you? Here we've picked out some of our favourite all-inclusive home VoIP providers.

Vonage

Best for bundled hardware

vonageforhome.co.uk
PRICE From £6.99 per month

Vonage is one of the best-known and longest-operating domestic VoIP providers serving the UK. It offers a phone line with a geographic number, including the option to port your existing number from a landline, or from Skype – and when you sign up you also get a free Vonage Box adapter to connect your existing handset to the VoIP network. This means you don't need to invest in any new hardware, and will pay only a fiver for delivery.

Vonage also offers the Vonage Extensions app, which turns your smartphone into an extension of your existing home number, allowing you to make and answer home calls wherever you happen to be. However, note that, although Vonage allows businesses to use their own SIP systems, home users must use the supplied Vonage box or smartphone apps.

To get onto Vonage you'll need to sign up to a plan, with prices starting at £6.99 per month (on a minimum one-year contract), plus a £10 activation fee. The price includes 1,000 monthly minutes of calls to UK landlines, after which calls cost 3p per minute (or 10p to mobiles), plus a per-call charge of 19p. If you choose not to port your existing number you'll be allocated a non-geographic number in the 03 code, or if you go for a premium plan (starting at £13.25 a month) you can choose a number in a specific area code.

The standard bundled minutes work out to just over half an hour every day, which should be enough for most people. Heavy users, however, should look at Vonage's unlimited packages: Talk UK costs £10.25 a month for unlimited calls to UK numbers, while Talk World (£14.75 per month) extends that to more than 60 additional countries, including Australia, the USA and Europe; there's also a specific Talk World India plan for £19 a month. These three extended plans incur the same £5 equipment delivery fee as Talk UK 1000, but the two World tiers drop the £10 activation fee. Just note that none of these plans includes unlimited calls to mobiles.

> Since VoIP lines aren't tied to a geographical exchange, you don't need to use a number from your own local area or country

Keeping your Skype number

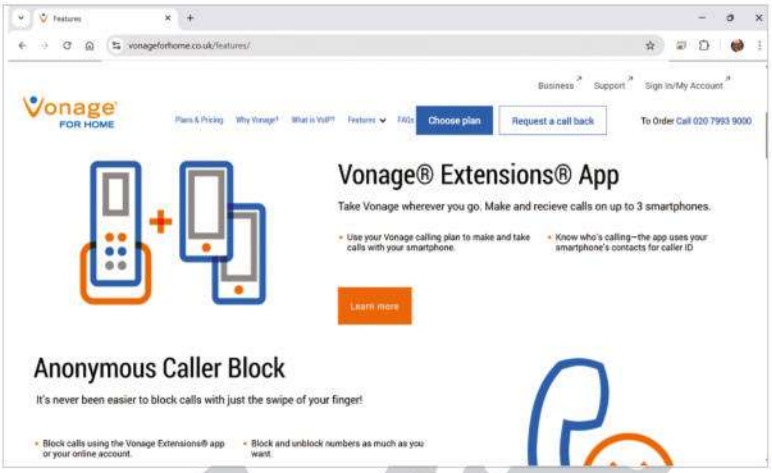
If you're a long-term VoIP user you could have been using your Skype phone number for as long as 20 years – in which case you probably don't want to lose it. It is possible to move an active Skype number to another VoIP provider, using the regular porting option that most platforms offer when you sign up. The catch is that little word "active": it may not be possible to keep your number after your Skype subscription has ended. In other words, if your number is still working and you want to keep it, act quickly.

Localphone

Best for cheap line rental

localphone.com
PRICE From 90p per month

If you're looking for a low-cost VoIP service for occasional use, Localphone could be the answer.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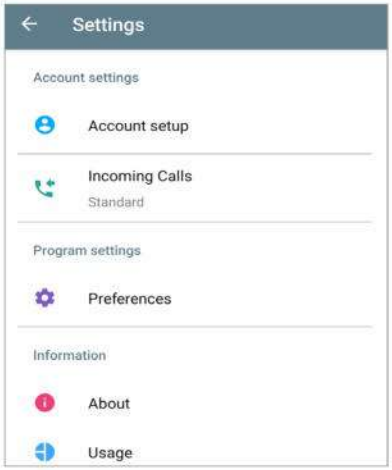
To Order Call 020 7993 9000
Vonage® Extensions® App
Take Vonage wherever you go. Make and recieve calls on up to 3 smartphones.
Use your Vonage calling plan to make and take calls with your smartphone.
Know who's calling—the app uses your smartphone's contacts for caller ID
Learn more
Anonymous Caller Block
It's never been easier to block calls with just the swipe of your finger!
Block calls using the Vonage Extensions® app or your online account.
Block and unblock numbers as much as you want.

BELOW **Vonage offers a phone line with a geographic number**

LEFT Localphone offers landline numbers in 54 countries

BELOW LEFT The Localphone app makes account management easy



If you're away from home, you can use Localphone's clever callback service from any phone in the world

It offers landline numbers in 54 countries, with line rental starting at just 90p inc VAT per month. There's a one-off setup fee of 90p for either a UK geographic number (from a selection of 630 area codes) or a non-geographic 03 number; mobile numbers are also available for £2.40. To discourage businesses from overloading the service, numbers are limited to receiving up to two incoming calls at once, and a 1p per call surcharge is applied to any number that exceeds 100 incoming calls per day, which shouldn't be a problem for home users.

Once you're up and running, calls cost 0.6p per minute to UK landlines, or 1.8p per minute to UK mobiles. Most US landlines and mobiles are actually cheaper, at 0.5p a minute, while it's 2.2p a minute to landlines and mobiles in India; for Australia you're looking at 1.1p a minute to a landline and 2.9p a minute to a mobile. Heavy users can save money by block-buying minutes, with country-specific call packages for 167 countries. If you'll primarily be calling UK numbers, you can buy 200, 400 or 800 minutes a month for £2.45, £4.50 and £8.45, which works out to 1.22p, 1.13p and 1.06p per minute respectively.

Localphone works with any standard SIP phone, or you can find yourself an analogue telephone converter box and keep your existing handset. You can also use Localphone's own smartphone app, or download a third-party SIP app such as Zoiper (**zoiper.com**).

Alternatively, if you're away from home, you can use Localphone's clever callback service from any phone in the world. Just call the number, then hang up when you hear the greeting; the service will then call you back and prompt you to enter your destination number. You'll pay for both parts of the call – for example, if you're in Canada and want to call Australia, you'll pay 0.4p per minute for the Canadian portion of the call, plus 1.1p per minute for the Australian connection – but that will probably still be cheaper than calling direct. You can also use Localphone to send international SMS messages without paying your mobile service provider's global texting rates.

Xinix

Best for bring-your-own hardware

xinix.co.uk
PRICE From £7 per month

Xinix isn't just a telecoms provider – it also offers its own broadband service. However, since VoIP works entirely over the internet, there's no reason why you can't sign up for a Xinix call package while keeping your current ISP. Prices start at £7 a month for a 24-month commitment, paid annually at £84 a year – or if you prefer monthly billing it's £9 per month. Calls to UK landlines cost 5p a minute, while to mobiles it's 12p. Setup is free, but porting your existing number costs £20.

If you make more than 40 minutes of landline calls in a month (or 17 minutes of mobile calls) it makes sense to sign up for the Xinix Standard plan, which costs £9 and gives you 500 bundled landline and mobile minutes – or you can pay just £1 extra for unlimited minutes. Calls to many popular international destinations cost 5p a minute, including the USA, India, Australia and several European countries, while in-network calls are free, so if your friends and family also sign up to Xinix you can call them at no charge.

As well as not requiring you to have a Xinix internet line, the

How to use your VoIP landline

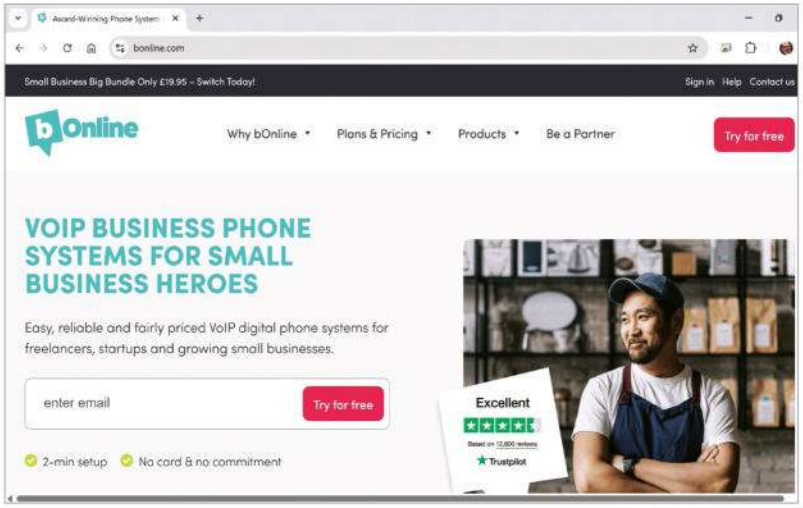
If you're switching away from a regular landline, that doesn't mean you have to throw out your phone. Many ISP routers come with a phone socket that lets you plug in a standard phone and use it with the provider's own VoIP service.

If you're sourcing your "landline" from a third party, you usually have a few different handset options. The simplest approach is to use an analogue telephone adapter (ATA) to connect your existing analogue phone to the VoIP network.

One popular model is the Grandstream HT801, which lets you continue using the phone exactly as you're used to: just pick up the receiver and dial, and the box will handle everything in the background. If you want to run multiple lines, however, you'll need something more advanced.

If you want more versatility, you can buy a dedicated SIP phone – that is, one that's designed for the Session Initiation Protocol, which deals with making and receiving VoIP calls. My now discontinued Yealink T48S SIP desk phone connects to the router via Wi-Fi and has a 7in colour display, an integrated phone book, call recording to a USB storage device and support for up to 16 different VoIP accounts. Needless to say, there can be a learning curve with advanced SIP phones, as well as a price premium: costs range from around £40 for the simplest models to more than £230 for a top-of-the-range model.

The cheapest option is to skip the hardware entirely and use an app. Your chosen provider may offer its own calling software, or you can usually use a free third-party solution such as Zoiper, which is available for both desktop and mobile platforms. Install this on your smartphone and you'll be able to access your VoIP line from anywhere.



provider is quite liberal about how you use its service. If you already have an analogue phone that you're happy with, Xinix will send you an analogue telephone adapter for just the £8 shipping fee. Alternatively, you can use any SIP-compatible handset, or make and answer calls using Xinix' mobile and PC apps. Up to five devices can be connected to your account, and the browser interface also lets you manage call forwarding, set up call-handling rules for daytime and nighttime and listen to your voicemails from anywhere, giving you a lot more versatility than most other home VoIP platforms.

bOnline
Best for home workers

bonline.com
PRICE From £7 per month

If you're looking for a VoIP number for a home-based business, bOnline could be the answer. Its starter plan for freelancers, startups and small businesses comes with a seven-day free trial. This then costs £7 per user per month, and includes a phone number and 100 minutes of outbound landline calls. The contract runs for a minimum of 12 months, and you can connect using any standard SIP-based hardware or app.

As a business-focused service, bOnline offers a good spread of professional features. For example, the service can pick up multiple calls simultaneously, greet callers with a recording or text-to-speech script, and place them on hold if you're busy, until you're able to disengage yourself from your current call and switch over. In the browser interface you can also set closed hours and holiday dates, during which calls will be routed directly to voicemail, or create menus that callers can navigate using their keypad.

ABOVE The bOnline starter plan costs £7 a month, and includes a phone number and 100 minutes of outbound landline calls

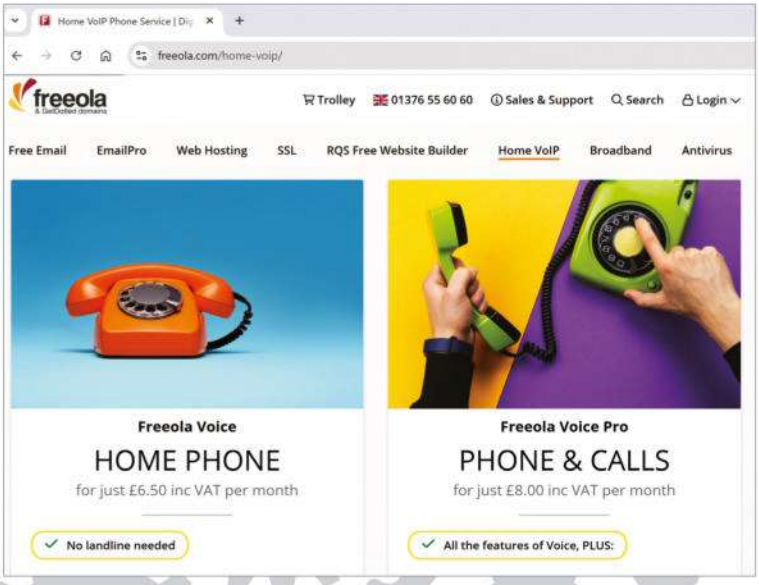
You can also add additional lines to your account, and make calls between them for free. Calls to UK geographic landline numbers cost 2p a minute plus a 5p setup charge, or you can upgrade to unlimited calls for £13.95 per user per month (currently discounted to £9.95 per user per month for the first half of a 12- or 24-month contract). bOnline also offers a number of call packages for heavy users, along with international deals that give you unlimited calls to landlines (and some mobiles) in 14 countries, including France, Italy, the USA and Australia.

Calling emergency services

A VoIP phone can do very nearly everything a traditional phone line can, but it's important to understand that you may not be able to contact the emergency services from a VoIP phone in the way you're used to.

This is partly because VoIP numbers aren't tied to a specific address; you can register a number in any area code, even one hundreds of miles from your home. If that's a concern, check before you sign up: some services, including Freeola and Vonage, register your number to a specific street address, so emergency services can see where you're likely calling from.

Another issue is power. Traditional phone lines carried their own 48V power supply, which meant they could keep working even if the mains power went out. VoIP, however, relies on your router and internet connection being powered and working – so in a major disaster, your phone line might well be inaccessible. It's best to keep your mobile charged, or make other arrangements, just in case disaster strikes.



BELOW Freeola offers two VoIP services for home users

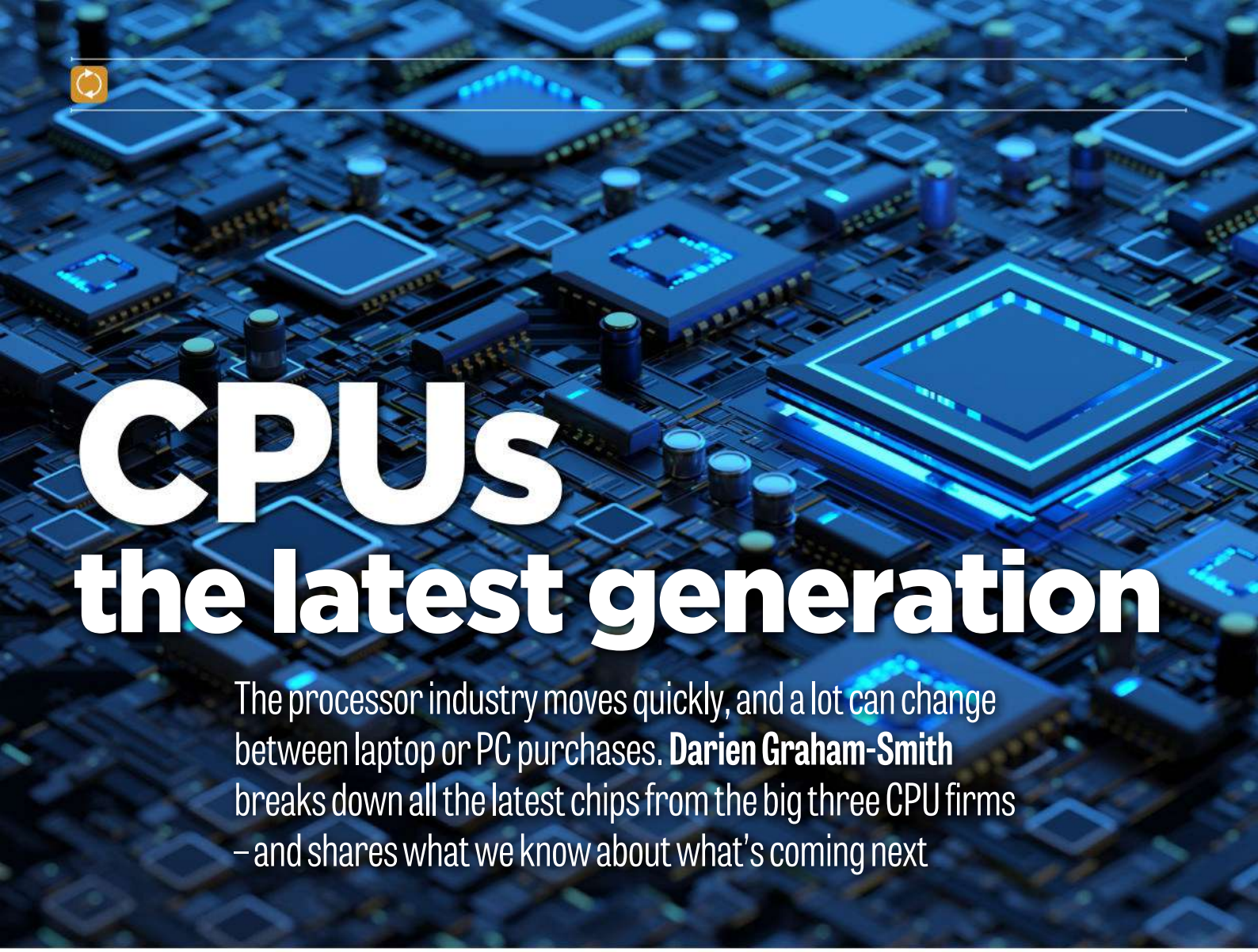
Freeola
Best for bundled calls

freeola.com
PRICE From £6.50 per month

Freeola offers two services for home users: the basic Voice service costs £6.50 a month, or for an extra £1.50 you can move up to Voice Pro, which includes 500 minutes of calls to UK landlines and 500 to UK mobiles. You can register a new UK geographic number when you sign up, or port your existing number for £19.20; as is usual with VoIP providers, the porting process can take around ten days to complete, but you'll be assigned a temporary number in the meantime.

If you already have your own SIP-compatible equipment then you can use that with the service. If you need a handset then Freeola can supply DECT handsets with IP base stations, or a Grandstream HT801 phone adapter for existing handsets. Opt for the latter, and it's currently discounted by £20 (down to £30).

Calling a UK geographic number with Freeola costs 0.9p a minute, while mobiles cost 3.6p a minute, and mobiles on the Isle of Man or in the Channel Islands are 28.8p a minute. Calls to European landlines vary: Poland costs 2.28p a minute, France is 1.53p per minute, Spain 0.55p and Germany costs just 0.49p a minute.



CPUs the latest generation

The processor industry moves quickly, and a lot can change between laptop or PC purchases. **Darien Graham-Smith** breaks down all the latest chips from the big three CPU firms – and shares what we know about what's coming next

AMD

AMD's Ryzen processors have always been popular with cost-conscious shoppers seeking performance on a budget. One reason for this is that AMD generally manages to cram more cores into its chips than competing Intel models. AMD long ago outsourced its chip production to Taiwan-based specialist TSMC, so it's been able to take advantage of industry-leading manufacturing processes; as a result, very complex chips with a dozen cores or more can be reliably manufactured with smaller and smaller process sizes. Meanwhile, as we noted last month, Intel has struggled to shrink its own in-house manufacturing processes, meaning it's been playing catch-up almost since the very first AMD Ryzen processor was released in 2017.

The latest AMD processors are based on the fifth major generation of its Zen core, officially dubbed "Zen 5", and internally codenamed "Nirvana" by AMD. This replaces the Zen 4 "Durango" core, introduced in 2022.

Chips based on the Zen 5 core are known either as the Ryzen 9000 series or as Ryzen AI for models that include a dedicated NPU. The core logic is the same across the whole range, which currently comprises eight desktop chips and 13 mobile processors – not to mention 27 server-oriented Zen 5 chips sold under AMD's Epyc brand.

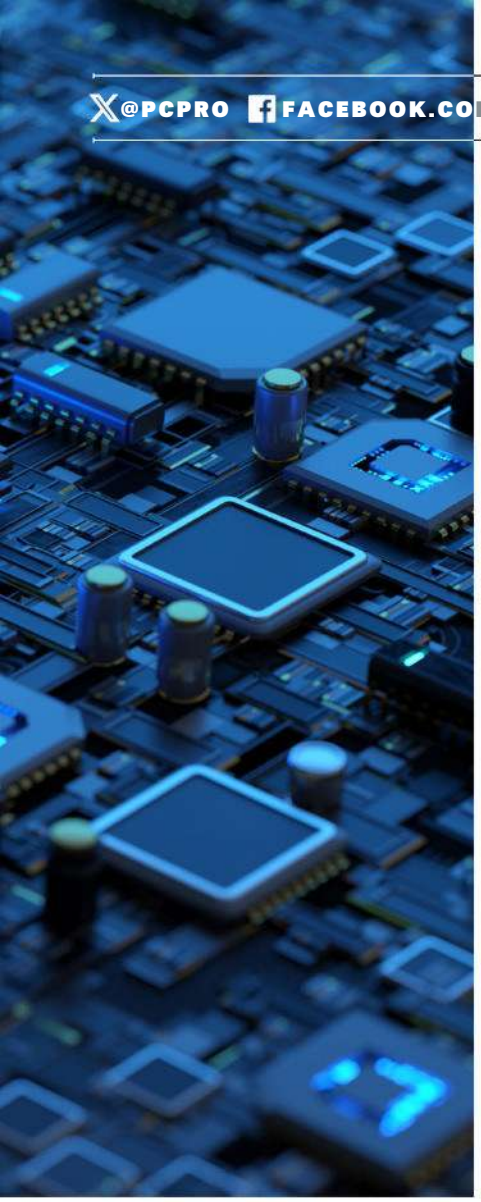
The consumer chips covers a wide spread of capabilities (*see p44*). As well as differing core counts and clock frequencies, different models include different GPU and NPU hardware and varying quantities of cache. The X3D" models have an extra-large 128MB L3 cache to boost performance in games and other demanding applications – it's called 3D cache because it's physically stacked on top of the regular cache. Many models are also available in "Pro" variants, which (similarly to Intel's vPro technology) include business-oriented management and platform-security features, but are otherwise identical.

What makes Zen 5 special is that it's the first mainstream core that can work two steps ahead

Inside, all of these chips are built on TSMC's N4X process. Despite the name, this is officially a 5nm process, but it features enhancements that, TSMC claims, boost performance by up to 15% compared to the original 5nm process used for Zen 4.

Another advantage of Zen 5 chips is new branch prediction logic. Branch prediction is a CPU feature that tries to speed up code execution by anticipating what will happen after the current instruction, and presumptively starting to load in and work on the expected next instruction before it's needed. All modern processors use branch prediction, but what makes Zen 5 special is that it's the first mainstream core from any manufacturer that can actually work two steps in advance.

To enable the core to work so far ahead, Zen 5-based chips also include more ultra-high-speed cache than previous AMD processors, with the L1 cache being increased from 64KB per core to 80KB. The standard L2 cache remains at 1MB per core, as it



was in Zen 4, while L3 cache varies depending on the chip model.

The Zen 5 core also features six arithmetic logic units, up from four in previous models – boosting mathematical performance by up to 50% – plus an expanded vector engine that can speed up processing of large data arrays, including AI-type workloads. For those wanting to use the very fastest memory modules, Zen 5 also supports DDR5-5600 – a modest increase from the maximum DDR5-5200 supported by Zen 4.

What's next for AMD?

Zen 5 is fairly new, with the first mobile chips appearing in June 2024 and new models last month. Based on previous upgrade cycles, we don't expect Zen 6 (codenamed Morpheus) to make its debut until next year.

AMD hasn't officially announced what enhancements might be included in the next core, but leaks suggest it will increase the maximum number of cores per chip. This means we could see desktop chips with as many as 24 physical cores, along with 96MB of L3 cache as standard. However, there are no major platform changes on the horizon, and Zen 6 is expected to stick with the established Socket AM5 interface.

Intel

Last month, we described a generation of processors as a family of chips all based on the same core design. That's generally true, but recent years have seen Intel race through updates to its manufacturing processes in a bid to remain competitive – and as a result, its current processor line-up, branded as second-generation Core and Core Ultra chips, actually takes in three different cores across a total of 47 different CPU models.

That includes seven processors using the "Raptor Lake Refresh" core, a refinement of the Raptor Lake architecture introduced in 2022 for the 13th- and 14th-generation Core i CPUs. A further 32 models are based on Arrow Lake, a newer design aimed at desktops and high-end laptops, while the remaining nine chips are built on Lunar Lake, a mobile-only core with a focus on power efficiency.

To help make sense of the situation, most model numbers have suffixes that explain the chip's profile. On the desktop side, the "K" suffix indicates a top-performance chip with unlocked multipliers, while "T" denotes a desktop processor designed for lower power consumption. "F" indicates a chip with no GPU. For mobile processors, "H" means a high-performance design, while "HX" is a high-end chip that also includes Intel's vPro management technology. "U" processors are more power-efficient, while "V" denotes a chip using the unique Lunar Lake architecture, discussed below.

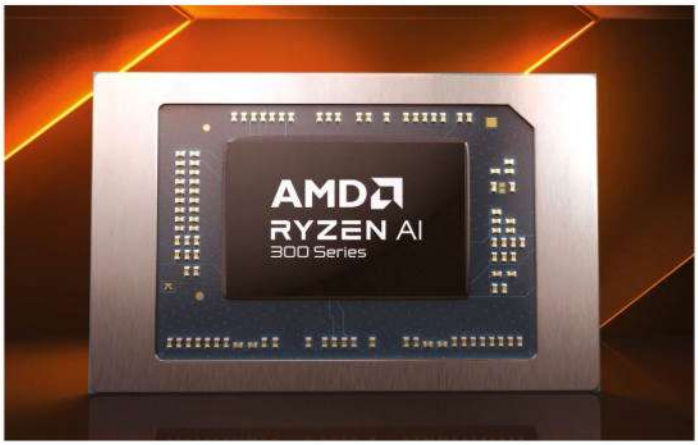
For future chips, Intel will be returning to in-house manufacturing

As usual, the distinctions between different chip models partly boil down to the number and speed of CPU and GPU cores, and the amount of cache memory embedded on the chip. Unlike older Intel CPUs, all second-generation Core processors use a mixture of high-performance "P-cores" and energy-efficient "E-cores", so there's plenty of scope to tune different chips for different balances of power and performance.

With three different cores in the mix, however, the differences run deeper. For example, chips based on Arrow Lake all include a lightweight NPU rated at 12 or 13 TOPS, while the older Raptor Lake Refresh lacks specialised AI hardware. Conversely, Raptor Lake chips use Hyper-Threading technology in their P-cores, allowing them to handle two execution threads at once – a capability removed from the latest processors in the name of efficiency.

Lunar Lake, meanwhile, has a very different design, including an NPU of at least 40 TOPS that qualifies for Microsoft's "Copilot+ PC" branding. Lunar Lake chips also break with tradition by including either 16GB or 32GB of integrated (non-upgradable) system RAM on the processor itself – and these chips also have the distinction of being the only Intel chips ever to be manufactured by a third party, in this case TSMC. That's a one-off, however: for future chips, Intel will be returning to in-house manufacturing, and also intends to go back to using outboard DIMMs rather than on-package memory.

Finally, it's worth noting that different chip models also have different GPU



BELOW AMD's Zen 5 chips include extra ultra-high-speed cache

BOTTOM Seven Intel chips use the Raptor Lake Refresh core

CPU GENERATIONS

AMD

Model number	Platform	Physical cores	Threads	Base clock	Boost clock	GPU cores	GPU clock (max)	NPU	L1 cache	L2 cache	L3 cache	Codename	Process size	Release date
Ryzen 9 9950X3D	Desktop	16	32	4.3GHz	5.7GHz	2	2.2GHz	None	1,280KB	16MB	128MB	Granite Ridge	5nm	March 2025
Ryzen 9 9950X	Desktop	16	32	4.3GHz	5.7GHz	2	2.2GHz	None	1,280KB	16MB	64MB	Granite Ridge	5nm	August 2024
Ryzen 9 9900X3D	Desktop	12	24	4.4GHz	5.5GHz	2	2.2GHz	None	960KB	12MB	128MB	Granite Ridge	5nm	March 2025
Ryzen 9 9900X	Desktop	12	24	4.4GHz	5.6GHz	2	2.2GHz	None	960KB	12MB	64MB	Granite Ridge	5nm	August 2024
Ryzen 7 9800X3D	Desktop	8	16	4.7GHz	5.2GHz	2	2.2GHz	None	640KB	8MB	96MB	Granite Ridge	5nm	November 2024
Ryzen 7 9700X	Desktop	8	16	3.8GHz	5.5GHz	2	2.2GHz	None	640KB	8MB	32MB	Granite Ridge	5nm	August 2024
Ryzen 5 9600X	Desktop	6	12	3.9GHz	5.4GHz	2	2.2GHz	None	480KB	6MB	32MB	Granite Ridge	5nm	August 2024
Ryzen 5 9600	Desktop	6	12	3.8GHz	5.2GHz	2	2.2GHz	None	480KB	6MB	32MB	Granite Ridge	5nm	TBC
Ryzen AI MAX+ (PRO) 395	Mobile	16	32	3GHz	5.1GHz	40	2.9GHz	50 TOPS	1,280KB	16MB	64MB	Strix Halo	5nm	March 2025
Ryzen AI MAX (PRO) 390	Mobile	16	32	3.2GHz	5GHz	32	2.8GHz	50 TOPS	1,280KB	16MB	64MB	Strix Halo	5nm	March 2025
Ryzen AI MAX (PRO) 385	Mobile	8	16	3.6GHz	5GHz	32	2.8GHz	50 TOPS	640KB	8MB	32MB	Strix Halo	5nm	March 2025
Ryzen AI MAX PRO 380	Mobile	6	12	3.6GHz	4.9GHz	16	2.8GHz	50 TOPS	480KB	6MB	16MB	Strix Halo	5nm	March 2025
Ryzen 9 9955HX3D	Mobile	16	32	2.3GHz	5.4GHz	2	2.2GHz	None	1,280KB	16MB	128MB	Fire Range	5nm	March 2025
Ryzen 9 9955HX	Mobile	16	32	2.5GHz	5.4GHz	2	2.2GHz	None	1,280KB	16MB	64MB	Fire Range	5nm	March 2025
Ryzen 9 9850HX	Mobile	12	24	3GHz	5.2GHz	2	2.2GHz	None	960KB	12MB	64MB	Fire Range	5nm	March 2025
Ryzen AI 9 (PRO) HX375	Mobile	12	24	2GHz	5.1GHz	16	2.9GHz	55 TOPS	960KB	12MB	24MB	Strix Point	5nm	June 2024
Ryzen AI 9 (PRO) HX370	Mobile	12	24	2GHz	5.1GHz	16	2.9GHz	50 TOPS	960KB	12MB	24MB	Strix Point	5nm	June 2024
Ryzen AI 9 HX365	Mobile	10	20	2GHz	5GHz	12	2.9GHz	50 TOPS	800KB	10MB	24MB	Strix Point	5nm	June 2024
Ryzen AI 7 PRO 360	Mobile	8	16	2GHz	5GHz	12	2.9GHz	50 TOPS	640KB	8MB	16MB	Strix Point	5nm	October 2024
Ryzen AI 7 (PRO) 350	Mobile	8	16	2GHz	5GHz	8	3GHz	50 TOPS	640KB	8MB	16MB	Strix Point	5nm	March 2025
Ryzen AI 7 (PRO) 340	Mobile	6	12	2GHz	4.8GHz	4	2.9GHz	50 TOPS	480KB	6MB	16MB	Strix Point	5nm	March 2025

INTEL

Model number	Platform	P-cores	P-core base clock	P-core maximum boost	E-cores	E-core base clock	E-core maximum boost	Integrated RAM	GPU cores	GPU clock (max)	NPU	L1 cache	L2 cache	Smart cache	Codename	Process size	Release date
Core Ultra 9 285K	Desktop	8	4.3GHz	5.7GHz	16	3.2GHz	4.6GHz	None	4	2GHz	13 TOPS	2.4MB	40MB	36MB	Arrow Lake-S	3nm	October 2024
Core Ultra 9 285	Desktop	8	2.5GHz	5.6GHz	16	1.9GHz	4.6GHz	None	4	2GHz	13 TOPS	2.4MB	40MB	36MB	Arrow Lake-S	3nm	January 2025
Core Ultra 9 285T	Desktop	8	1.4GHz	5.4GHz	16	1.2GHz	4.6GHz	None	4	2GHz	13 TOPS	2.4MB	40MB	36MB	Arrow Lake-S	3nm	October 2024
Core Ultra 7 265K	Desktop	8	3.9GHz	5.5GHz	12	3.3GHz	4.6GHz	None	4	2GHz	13 TOPS	2MB	36MB	30MB	Arrow Lake-S	3nm	October 2024
Core Ultra 7 265KF	Desktop	8	3.9GHz	5.5GHz	12	3.3GHz	4.6GHz	None	None	N/A	13 TOPS	2MB	36MB	30MB	Arrow Lake-S	3nm	October 2024
Core Ultra 7 265	Desktop	8	2.4GHz	5.3GHz	12	1.8GHz	4.6GHz	None	4	1.95GHz	13 TOPS	2MB	36MB	30MB	Arrow Lake-S	3nm	January 2025
Core Ultra 7 265F	Desktop	8	2.4GHz	5.3GHz	12	1.8GHz	4.6GHz	None	None	N/A	13 TOPS	2MB	36MB	30MB	Arrow Lake-S	3nm	January 2025
Core Ultra 7 265T	Desktop	8	1.5GHz	5.3GHz	12	1.2GHz	4.6GHz	None	4	1.95GHz	13 TOPS	2MB	36MB	30MB	Arrow Lake-S	3nm	January 2025
Core Ultra 5 245K	Desktop	6	4.2GHz	5.2GHz	8	3.6GHz	4.6GHz	None	4	1.9GHz	13 TOPS	1.4MB	26MB	24MB	Arrow Lake-S	3nm	October 2024
Core Ultra 5 245KF	Desktop	6	4.2GHz	5.2GHz	8	3.6GHz	4.6GHz	None	None	N/A	13 TOPS	1.4MB	26MB	24MB	Arrow Lake-S	3nm	October 2024
Core Ultra 5 245	Desktop	6	3.5GHz	5.1GHz	8	3GHz	4.5GHz	None	4	1.9GHz	13 TOPS	1.4MB	26MB	24MB	Arrow Lake-S	3nm	January 2025
Core Ultra 5 245T	Desktop	6	2.2GHz	5.1GHz	8	1.7GHz	4.5GHz	None	4	1.9GHz	13 TOPS	1.4MB	26MB	24MB	Arrow Lake-S	3nm	January 2025
Core Ultra 5 235	Desktop	6	3.4GHz	5GHz	8	2.9GHz	4.4GHz	None	3	2GHz	13 TOPS	1.4MB	26MB	24MB	Arrow Lake-S	3nm	January 2025
Core Ultra 5 235T	Desktop	6	2.2GHz	5GHz	8	1.6GHz	4.4GHz	None	3	2GHz	13 TOPS	1.4MB	26MB	24MB	Arrow Lake-S	3nm	January 2025

Core Ultra 5 225	Desktop	6	3.3GHz	4.9GHz	4	2.7GHz	4.4GHz	None	2	1.8GHz	13 TOPS	1MB	22MB	20MB	Arrow Lake-S	3nm	January 2025
Core Ultra 5 225F	Desktop	6	3.3GHz	4.9GHz	4	2.7GHz	4.4GHz	None	None	N/A	13 TOPS	1MB	22MB	20MB	Arrow Lake-S	3nm	January 2025
Core Ultra 5 225T	Desktop	6	2.5GHz	4.9GHz	4	1.9GHz	4.4GHz	None	2	1.8GHz	13 TOPS	1MB	22MB	20MB	Arrow Lake-S	3nm	January 2025
Core Ultra 7 265U	Mobile	2	2.1GHz	5.3GHz	8	1.7GHz	4.2GHz	None	4	2.1GHz	12 TOPS	1MB	8MB	12MB	Arrow Lake-U	3nm	January 2025
Core Ultra 7 255U	Mobile	2	2GHz	5.2GHz	8	1.7GHz	4.2GHz	None	4	2.1GHz	12 TOPS	1MB	8MB	12MB	Arrow Lake-U	3nm	January 2025
Core Ultra 5 235U	Mobile	2	2GHz	4.9GHz	8	1.6GHz	4.1GHz	None	4	2.05GHz	12 TOPS	1MB	8MB	12MB	Arrow Lake-U	3nm	January 2025
Core Ultra 5 225U	Mobile	2	1.5GHz	4.8GHz	8	1.3GHz	3.8GHz	None	4	2GHz	12 TOPS	1MB	8MB	12MB	Arrow Lake-U	3nm	January 2025
Core 7 250U	Mobile	2 (4)	1.8GHz	5.4GHz	8	1.2GHz	4GHz	None	96*	1.3GHz	None	1MB	8MB	12MB	Raptor Lake-U Refresh	3nm	January 2025
Core 5 220U	Mobile	2 (4)	1.4GHz	5GHz	8	900MHz	3.8GHz	None	80*	1.3GHz	None	1MB	8MB	12MB	Raptor Lake-U Refresh	3nm	January 2025
Core Ultra 9 288V	Mobile	4	3.3GHz	5.1GHz	4	3.3GHz	3.7GHz	32GB	8	2.05GHz	48 TOPS	832	14MB	12MB	Lunar Lake	3nm	September 2024
Core Ultra 7 268V	Mobile	4	2.2GHz	5GHz	4	2.2GHz	3.7GHz	32GB	8	2GHz	48 TOPS	832	14MB	12MB	Lunar Lake	3nm	September 2024
Core Ultra 7 266V	Mobile	4	2.2GHz	5GHz	4	2.2GHz	3.7GHz	16GB	8	2GHz	48 TOPS	832	14MB	12MB	Lunar Lake	3nm	September 2024
Core Ultra 7 258V	Mobile	4	2.2GHz	4.8GHz	4	2.2GHz	3.7GHz	32GB	8	1.95GHz	47 TOPS	832	14MB	12MB	Lunar Lake	3nm	September 2024
Core Ultra 7 256V	Mobile	4	2.2GHz	4.8GHz	4	2.2GHz	3.7GHz	16GB	8	1.95GHz	47 TOPS	832	14MB	12MB	Lunar Lake	3nm	September 2024
Core Ultra 5 238V	Mobile	4	2.1GHz	4.7GHz	4	2.1GHz	3.5GHz	32GB	7	1.85GHz	40 TOPS	832	14MB	12MB	Lunar Lake	3nm	September 2024
Core Ultra 5 236V	Mobile	4	2.1GHz	4.7GHz	4	2.1GHz	3.5GHz	16GB	7	1.85GHz	40 TOPS	832	14MB	12MB	Lunar Lake	3nm	September 2024
Core Ultra 5 228V	Mobile	4	2.1GHz	4.5GHz	4	2.1GHz	3.5GHz	32GB	7	1.85GHz	40 TOPS	832	14MB	12MB	Lunar Lake	3nm	September 2024
Core Ultra 5 228V	Mobile	4	2.1GHz	4.5GHz	4	2.1GHz	3.5GHz	16GB	7	1.85GHz	40 TOPS	832	14MB	12MB	Lunar Lake	3nm	September 2024
Core 9 270H	Mobile	6 (12)	2.7GHz	5.8GHz	8	2GHz	4.1GHz	None	96*	1.55GHz	None	1.2MB	11.5MB	24MB	Raptor Lake-H Refresh	3nm	December 2024
Core 7 250H	Mobile	6 (12)	2.5GHz	5.4GHz	8	1.8GHz	4GHz	None	96*	1.55GHz	None	1.2MB	11.5MB	24MB	Raptor Lake-H Refresh	3nm	December 2024
Core 7 240H	Mobile	6 (12)	2.5GHz	5.2GHz	4	1.8GHz	4GHz	None	64*	1.55GHz	None	1MB	9.5MB	24MB	Raptor Lake-H Refresh	3nm	December 2024
Core 5 220H	Mobile	4 (8)	2.7GHz	4.9GHz	8	2GHz	3.7GHz	None	80*	1.5GHz	None	1.2MB	18MB	18MB	Raptor Lake-H Refresh	3nm	December 2024
Core 5 210H	Mobile	4 (8)	2.2GHz	4.8GHz	4	1.6GHz	3.6GHz	None	48*	1.4GHz	None	832KB	14MB	12MB	Raptor Lake-H Refresh	3nm	December 2024
Core Ultra 9 285H	Mobile	6	2.9GHz	5.4GHz	8	2.7GHz	4.5GHz	None	8	2.35GHz	13 TOPS	1.4MB	23MB	24MB	Arrow Lake-H	3nm	January 2025
Core Ultra 7 265H	Mobile	6	2.2GHz	5.3GHz	8	1.7GHz	4.5GHz	None	8	2.3GHz	13 TOPS	1.4MB	23MB	24MB	Arrow Lake-H	3nm	January 2025
Core Ultra 7 255H	Mobile	6	2GHz	5.1GHz	8	1.5GHz	4.4GHz	None	8	2.25GHz	13 TOPS	1.4MB	23MB	24MB	Arrow Lake-H	3nm	January 2025
Core Ultra 5 235H	Mobile	4	2.4GHz	5GHz	8	1.5GHz	4.4GHz	None	8	2.25GHz	13 TOPS	1.2MB	18MB	24MB	Arrow Lake-H	3nm	January 2025
Core Ultra 5 225H	Mobile	4	1.7GHz	4.9GHz	8	1.3GHz	4.3GHz	None	7	2.2GHz	13 TOPS	1.2MB	18MB	24MB	Arrow Lake-H	3nm	January 2025
Core Ultra 9 285HX	Mobile	8	2.8GHz	5.5GHz	16	2.1GHz	4.6GHz	None	4	2GHz	13 TOPS	2.4MB	36MB	36MB	Arrow Lake-HX	3nm	January 2025
Core Ultra 9 275HX	Mobile	8	2.7GHz	5.4GHz	16	2.1GHz	4.6GHz	None	4	1.9GHz	13 TOPS	2.4MB	36MB	36MB	Arrow Lake-HX	3nm	January 2025
Core Ultra 7 265HX	Mobile	8	2.6GHz	5.3GHz	12	2.3GHz	4.6GHz	None	4	1.9GHz	13 TOPS	2MB	32MB	30MB	Arrow Lake-HX	3nm	January 2025
Core Ultra 7 255HX	Mobile	8	2.4GHz	5.2GHz	12	1.8GHz	4.5GHz	None	4	1.85GHz	13 TOPS	2MB	32MB	30MB	Arrow Lake-HX	3nm	January 2025
Core Ultra 5 245HX	Mobile	6	3.1GHz	5.1GHz	8	2.6GHz	4.5GHz	None	3	1.9GHz	13 TOPS	1.4MB	23MB	24MB	Arrow Lake-HX	3nm	January 2025
Core Ultra 5 235HX	Mobile	6	2.9GHz	5.1GHz	8	2.6GHz	4.5GHz	None	3	1.9GHz	13 TOPS	1.4MB	23MB	24MB	Arrow Lake-HX	3nm	January 2025

APPLE

Model number	Platform	P-cores	P-core maximum clock	E-cores	E-core maximum clock	Integrated RAM	GPU cores	GPU clock (max)	NPU	L1 cache	L2 cache	Process size	Release date
M3	Desktop & mobile	4	4.05GHz	4	2.75GHz	8GB/16GB/24GB	8/9/10	1.4GHz	18 TOPS	320KB per P-core + 192KB per E-core	20MB	3nm	November 2023
M3 Ultra	Desktop & mobile	20/24	4.05GHz	8	2.75GHz	96GB/128GB/256GB/512GB	60	1.47GHz	36 TOPS	320KB per P-core + 192KB per E-core	68MB	3nm	March 2025
M4	Desktop & mobile	3/4	4.4GHz	4/6	2.85GHz	8GB/16GB/24GB/32GB	8/10	1.47GHz	38 TOPS	320KB per P-core + 192KB per E-core	20MB	3nm	May 2024
M4 Pro	Desktop & mobile	8/10	4.5GHz	4	2.85GHz	24GB/48GB/64GB	16/20	1.58GHz	38 TOPS	320KB per P-core + 192KB per E-core	36MB	3nm	November 2024
M4 Max	Desktop & mobile	10/12	4.5GHz	4	2.85GHz	32GB/48GB/64GB/128GB	32/40	1.58GHz	38 TOPS	320KB per P-core + 192KB per E-core	36MB	3nm	November 2024

components. For the most part, you'll find between three and eight Intel Xe graphics cores on the chip, but Raptor Lake models use the older Intel UHD Graphics cores, with 48, 64, 80 or 96 execution units; we've marked these with asterisks in the table, as they're not comparable to the Xe cores.

What's next for Intel?

Later this year Intel is expected to launch a range of "Arrow Lake Refresh" chips, which will be marketed as the Core Ultra 300 series for both desktop and mobile systems. Going by previous "Refresh" launches, these chips will probably use the same core design as existing Arrow Lake chips, but with upgrades such as faster clock speeds and an improved NPU.

After that we can look forward to a completely new core codenamed "Panther Lake"; early silicon is expected to be showcased before the end of 2025, with mass production to follow in the first quarter of next year. The cautious timetable is because this will be the company's first 18A chip, representing a process size of 18 angstroms or 1.8nm – rivalling the smallest chips available from TSMC or any other foundry.

Technical details are still under wraps, but it's predicted that Panther Lake will be up to 13% faster than Arrow Lake, and could have as much as 120 TOPS of AI performance. If you're looking for a powerful AI laptop, therefore, it might be worth holding out until the next generation – but remember that these dates and features aren't officially confirmed.

Apple

Compared to the massive table of different Intel CPUs, Apple's lineup is refreshingly simple. Leaving aside the A-series processors in iPhones and a few other Apple gadgets, there are only five main chip models in use across almost every laptop and desktop in Apple's range. Two of these are pretty rare, too: the M3 and M3 Ultra are found only in the latest iPad Air and the top-spec Mac Studio respectively. If you buy any other Apple computer (or iPad Pro) today, you're getting the M4 chip, or a variant thereof.

The M4 isn't much of a change from the M3, and it's manufactured by TSMC on the same 3nm process. However, clock speeds are a little higher for both the CPU and GPU, and the newer chip has 20% more memory bandwidth, allowing it to tear through data at up to 120Gbits/sec. It also features a greatly souped-up NPU that's over twice as powerful as the M3's Neural Engine.

All of Apple's M-series processors include both P-cores and E-cores, like Intel's latest chips – but, unlike Intel, the system RAM is always built into the chip, too, so each model comes in a few variants to support different memory requirements.

ABOVE Apple's M4 chips are found in almost all of its laptop and desktop computers

Another difference between Apple and other chip makers is that the same processor models are used in both laptop and desktop computers, with generally similar clock speeds across the range. The company may however tweak the number of CPU and GPU cores to suit different roles: for example, the iPad Pro and the MacBook Air both use the M4 processor, but the version used in the iPad Pro has nine CPU cores and ten GPU cores, while entry-level MacBook Air laptops have ten CPU cores but only eight GPU cores. MacBook Pro models, meanwhile, get ten of each core, plus an active cooling system that helps the chip achieve peak performance.

Then there are the M4 Pro and M4 Max models; these are built on the same core logic as the M4, but are engineered with more cores than the standard models can support. Some additional features such as Thunderbolt 5 and 10Gbits/sec Ethernet are only offered on machines with M4 Pro or Max chips, although this is a marketing decision rather than a feature of the chips themselves.

Apple's most powerful Ultra chips are in effect two entire dies connected together

Apple's most powerful chips are its Ultra processors, which are in effect two entire dies connected together, giving you twice the cores, cache and RAM of a standard model. Apple isn't yet offering an M4 Ultra processor, so for now its top-of-the-line Mac Studio systems are based on the M3 Ultra – a chip that can still comfortably outpace any available M4 model (*see p52*).

What's next for Apple?

Apple is secretive about unreleased products, but it's a reasonable guess that the M4 family will be succeeded by an M5 generation of processors, probably before the end of the year.

As to what will changes these chips will bring, rumours are of a modest, incremental upgrade; it's the subsequent M6 processor that's expected to bring significant boosts to performance and power efficiency, partly thanks to a switch to a 2nm process. This doesn't necessarily you should skip the M5 generation, though: it should still bring advantages over the M4, and might come alongside other platform changes such as the introduction of Thunderbolt 5 for entry-level systems or support for Wi-Fi 7.

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Scan 3XS Evolve Studio Pro

Equally at home in gaming and (most) 3D content creation tasks, this is an ideal jack of both trades

SCORE ★★★★★

PRICE £4,167 (£5,000 inc VAT)
from tinyurl.com/369scan

Regular desktop processors are now so good that you don't necessarily need a workstation-focused CPU for professional creative work. This is particularly true if you want to game on the same system. For those who fit this category, AMD reckons it has a processor that will meet your needs perfectly: the Ryzen 9 with 3D V-Cache. We put the latest version through its paces in a system from British manufacturer Scan.

AMD's 3D V-Cache technology stacks additional layers of L3 cache on top of the CPU. This significantly increases capacity, without making the chip package bigger. The 3D versions of AMD Ryzen 9 processors have twice as much L3 cache as their non-3D equivalents. There's a 3D version of the Ryzen 7 as well, which has three times as much L3 cache as other Ryzen 7 and Ryzen 5 CPUs. This extra cache can provide considerable performance benefits for certain applications, including gaming and some (but not all, as we shall see) creative tasks.

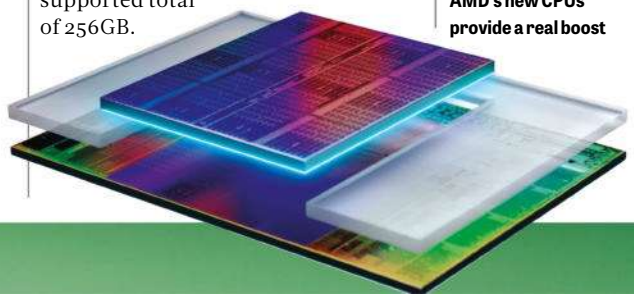
PC PRO ★★★★★ A-LIST

The Ryzen 9 9950X3D in our test system has 128MB of L3 cache, compared to the 9950X's 64MB. Otherwise, it has almost identical specifications to the non-3D version, with 16 cores all capable of running two threads for a total of 32 virtual cores. The base clock is 4.3GHz with a superb 5.7GHz top boost, which leads to a 170W thermal design power (TDP). So, this is a relatively power-hungry CPU.

Scan partners this top-end Ryzen 9 with an equally impressive pair of 32GB Corsair Vengeance 6000 DDR5 memory modules. These populate two of the four DIMM slots, leaving two more free for upgrade, up to the supported total of 256GB.

ABOVE Scan's 3XS Evolve Studio Pro is a powerful beast that looks stunning

"AMD's 3D V-Cache stacks additional layers of L3 cache on top of the CPU. This can provide considerable performance benefits"



BELOW The extra layers of L3 cache on AMD's new CPUs provide a real boost

However, 64GB will be fine for most tasks for the lifetime of this system.

Power boarding

There's been no skimping on the motherboard these components have are attached to, either. The Asus ProArt X870E-Creator WiFi is a premium model aimed at content creators and is packed with features. There's high-speed 10Gbits/sec and 2.5Gbits/sec networking available, plus dual USB-C 4. This latest version of USB delivers up to 120Gbits/sec in one direction or 80Gbits/sec bidirectionally, making it ideal for connecting ultra-high-speed external peripherals – assuming they support USB 4 as well.

For wireless connectivity, Wi-Fi 7 is built in with an aerial supplied. This is the latest WLAN standard, capable of offering similar throughput to wired gigabit Ethernet at short distances. However, the motherboard only has two PCI Express x16 slots, one of which is taken by the GPU.

Since this is a gaming PC with content creation capabilities on the

side, Scan has opted for a state-of-the-art consumer graphics card instead of a professional one. The GeForce RTX 5090 is the latest range-topper from Nvidia, with an almost unfeasible 21,760 CUDA cores and 32GB of GDDR7 memory on a 512-bit bus delivering 1,792GB/sec of bandwidth. This is a PCIe 5 peripheral, so can take full advantage of the CPU and motherboard's support for this high-throughput interconnect standard.

Although the 5090 is a gaming card first, Nvidia's Studio drivers mean it can be optimised for professional tasks, too. You can swap between drivers, depending on whether it's time for work or play.

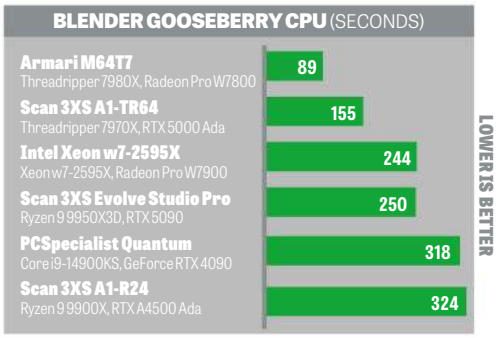
Hey, good looking

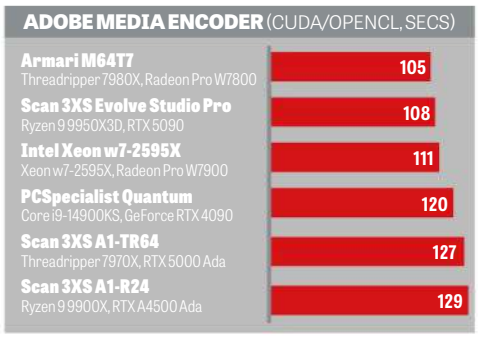
The Scan Evolve Studio Pro isn't just about its component choice, however. This is also a computer you won't need to hide away under your desk. The Fractal North Charcoal chassis is much more interesting visually than the typical black obelisks employed to house content creation workstations. In fact, the case looks like a stylish Scandinavian air conditioning unit – something you can be proud to show off to your friends. Nestling at the bottom is a Corsair 1,000W RMe series PSU, providing plenty of power for the energy-hungry core components.

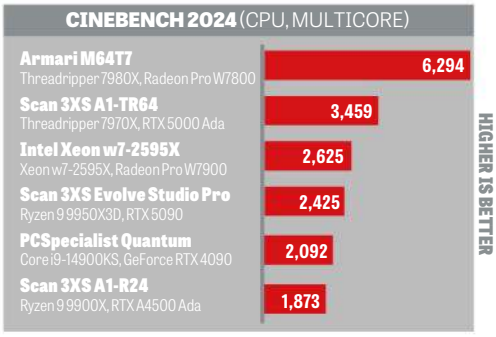
In fact, we measured a peak of 990W in our tests – although it's a little artificial, as we pushed the CPU to its max in Cinebench 2024 and simultaneously ran 3DMark. The GPU is the biggest power hog: running 3DMark alone required 785W, compared to 440W when rendering the Blender Gooseberry frame.

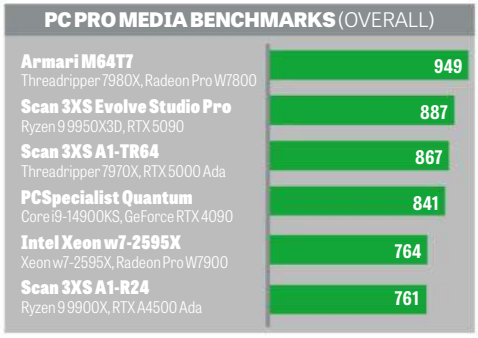
How fortunate that Scan doesn't overload the Evolve Studio Pro with extra RGB lighting, or it might have hit the 1,000W mark. Still, a window on the side of the chassis lets you admire the machine's innards. It's easy to remove this side panel with a couple of thumbscrews.

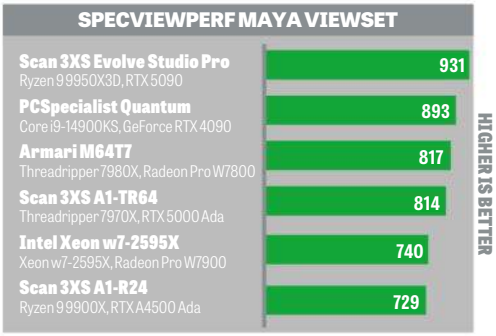
LEFT The RTX 5090 is a gaming card that can also be optimised for professional tasks

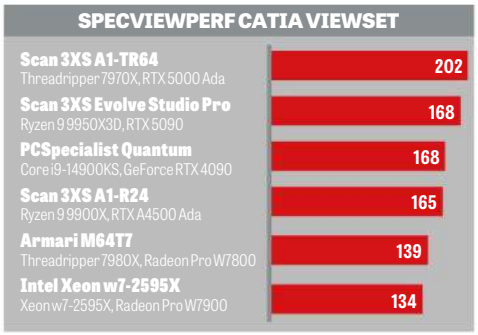












There are no 5.25in drive bays inside, so if you need an optical drive it will have to be external.

Adding other types of storage is much easier. You can install 3.5in trays in the bottom of the chassis for up to two 3.5in or 2.5in drives, or mount two 2.5in drives behind the motherboard. However, this entails removing the non-glass panel on the other side of the chassis.

The other option is M.2 via the motherboard. Scan has used this to supply the system's single storage device, but it's a good one – a 2TB Corsair MP700 Pro NVMe M.2 drive, which operates at PCIe 5 x4 speeds. This delivers exceptional 12,351MB/sec sustained reading and 11,942MB/sec writing, so bootup and software loading takes seconds. There's another M.2 slot for an additional drive, so you can have up to five devices on top of the supplied boot disk.

"Whether you're buying this system as a gaming PC first and a workstation second or the other way round, the performance is superb"

Smooth operator

To keep temperatures under control and the system as quiet as possible, Scan opts for Corsair's Nautilus 240 RS liquid CPU cooler. However, while this is a quiet system when idle, producing only 33dB from 1m distance, the fans spin up to produce a noticeable 42dB when involved in heavy activity such as 3D rendering. Still, this is an entirely bearable level of noise and not intrusive.

Whether you're buying this system as a gaming PC first and a workstation second or the other way round, the performance is superb. I tested the Evolve Studio Pro's gaming prowess

with the latest edition of 3DMark, using the Steel Nomad DX12 benchmark and the Nvidia Game Ready GPU drivers. The system managed a score of 14,159. The top systems are currently exceeding 17,000, so the Evolve Studio Pro isn't far off the best gaming performance currently available.

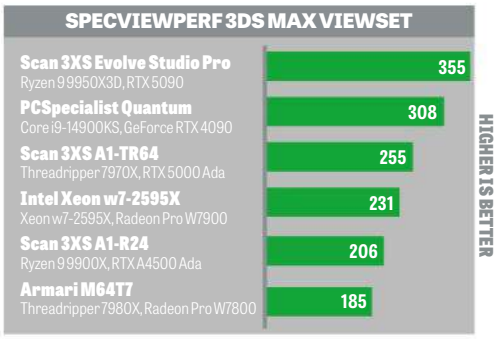
This system reigns supreme with most content creation tasks, too. A score of 887 in our media-creation benchmarks would have placed second in last year's workstation Labs test (*see issue 361, p78*), beaten only by Armari's Magnetar MC64T7-AW1650G4 – which has four times as many CPU cores and costs £9,994. The Maxon Cinebench multithreaded result of 2,625 and Blender Gooseberry CPU render time of 250 seconds put this in perspective. These results are only slightly behind Intel's Xeon w7-2595X (*see issue 363, p52*), which has 24 cores compared to the Evolve Studio Pro's 16. This is workstation-class rendering performance from a desktop CPU. Video encoding is incredible, too, with amazing scores both in this portion of the *PC Pro* benchmarks and with Adobe Media Encoder.

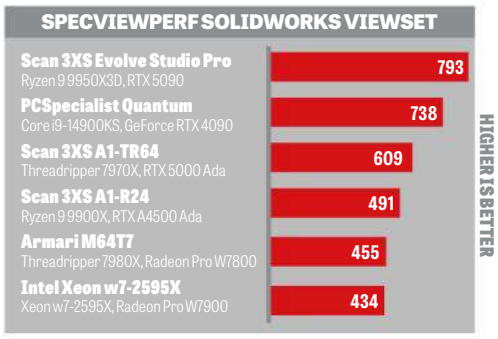
3D power play

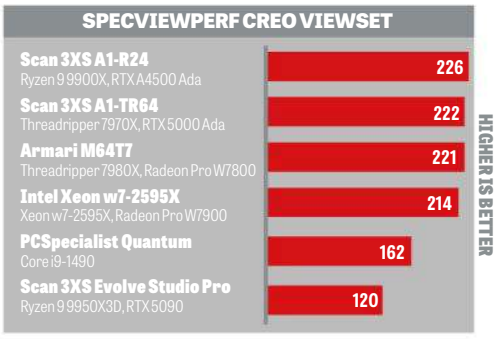
The Asus TUF Gaming GeForce RTX 5090 32GB graphics card has performance in spades too, even in some professional workloads. However, this is not true across *all* professional workloads.

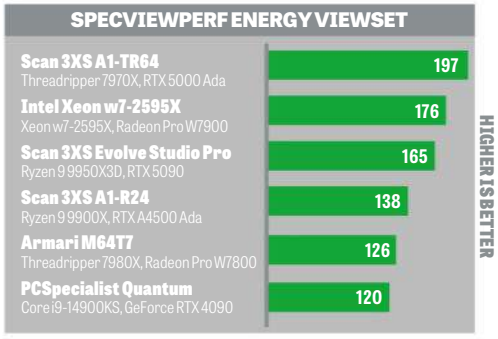
Let's start with strengths. System integrators have been telling us for years that many content creators specify consumer GPUs for activities such as 3D animation or game design. For the latter a GeForce card makes sense, so you can test your code on the same system you use for design.

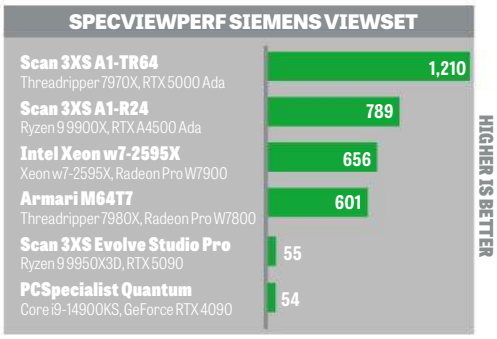
LEFT The Fractal North Charcoal chassis is free of RGB frippery

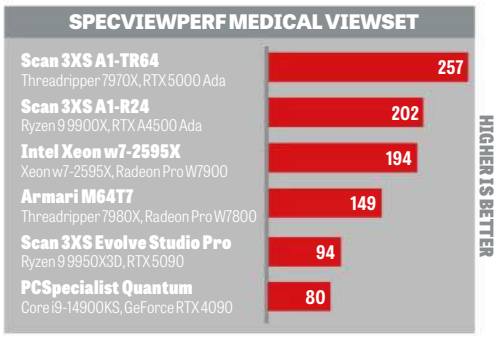












Using the Nvidia Studio drivers with SPECviewperf 2020 v3.1, we achieved 355 in the 3ds Max viewset and a gobsmacking 931 in Maya. The former is the highest score we've seen and the latter the second highest. In other words, with 3ds Max or Maya you're going to enjoy silky-smooth viewports as you animate.

The Scan system's performance in CAD and engineering tasks is more chequered. The Catia result of 168 is mid-range, and a return of 132 in the Creo viewset on the low side, but the SolidWorks score of 793 is the fastest we've seen by some distance. The runt of the litter is snx-04, representing Siemens NX, with the Evolve Studio Pro managing a score of only 55.

Overall, the Scan 3XS Evolve Studio Pro is a tour de force for most activities. If you're a gamer who designs games or animates 3D on the side, there's performance here in spades. If you model with SolidWorks, it's class-leading too. For other CAD applications you should opt for a professional GPU instead of the GeForce, but otherwise this is one the most potent all-round PCs we've tested. Arguably, it's the best all-round PC ever. **JAMES MORRIS**

"The Scan 3XS Evolve Studio Pro is a tour de force. If you're a gamer who designs games or animates 3D on the side, there's performance here in spades"

SPECIFICATIONS

8-core/16-thread AMD Ryzen 9 9950X3D processor • Asus ProArt X870E-Creator motherboard • 64GB Corsair Vengeance DDR5-6000 RAM • 32GB Asus TUF Gaming GeForce RTX 5090 graphics • Corsair Nautilus 240 RS liquid cooler • 2TB Corsair MP700 Pro PCIe Gen 5 SSD • Fractal North Charcoal chassis • 1,000W Corsair RMe Series PSU • Windows 11 Pro • 215 x 447 x 469mm (WDH) • 3yr warranty (1yr on-site, 2yr RTB, parts and labour) • power: 160W idle, 990W peak

How we test

Laptops and PCs

We run a selection of benchmarks on all the PCs and laptops we test. Where possible, we use a cross-platform test so we can compare Windows and macOS machines, which is where both Geekbench and Cinebench come into play. Both push the CPU to its limit, exposing how well cooled a system is.

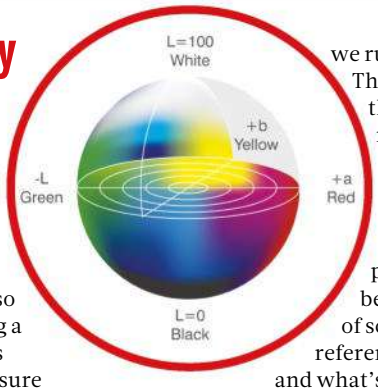
We run extra tests for Windows systems. We use PCMark 10 to benchmark systems in office tasks, content creation and basic tasks such as web browsing and video calls. We also run 3DMark Time Spy and *Shadow of the Tomb Raider* as a minimum. We test laptops and PCs that include discrete graphics with a range of games, such as *Metro Exodus Enhanced* and *Dirt 5*.

For laptops, we test battery life with Wi-Fi on and the screen brightness set to 150cd/m². We fully charge the laptops and drain them until they reach 5%. For Windows laptops, we will use a mix of PCMark 10's light-use and video-based tests, or a web surfing benchmark where a laptop automatically visits sites until the battery dies. We also use this test for MacBooks.

ABOVE We put PCs and laptops through our intensive set of benchmarks

Screen quality

In each laptop, phone, tablet and monitor review, you'll see our conclusions about the screen quality. Some of this will be subjective, but we also test each screen using a X-Rite Display i1 Plus colorimeter. We measure maximum brightness, colour accuracy and (for monitors) consistency – there may be a difference in, say, brightness from the middle and the edges of the panel.



LEFT We use a Display i1 colorimeter to measure sRGB gamut coverage and Delta E

We also measure Delta E, which is a guide to how accurately panels display colours. Anything under 1 is excellent and likely to be difficult for the human eye to distinguish; between one and two is still strong; above this suggests a panel that you shouldn't trust for colour-accurate photo editing.

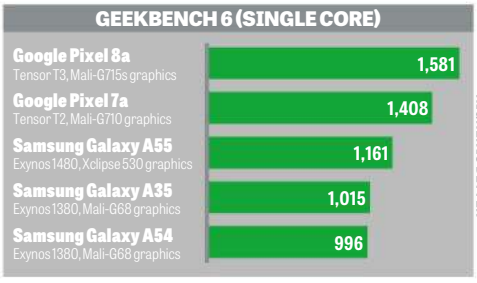
Phones and tablets

We run a selection of publicly available benchmarks on all the phones and tablets we review. First, we run Geekbench 6. This is a good test of the processor and memory in particular, and include both a test for single-core and multicore performance. See below for a selection of scores to provide a reference of what's good... and what's not so good.

We also run 3DMark Wild Life test to give a measure of gaming performance.

We test tablet battery life by playing a full-screen video until the battery runs out with the device. To simplify the test, we use Airplane mode. We set the brightness to as close to 150cd/m² as we can get in the device's settings. We also put phones through a set of real-world and labs-based tests.

BELOW We play a video with the screen set to 150cd/m² to test battery life



What our awards mean

Recommended
This, quite simply, is a product we recommend you buy – if it meets your needs.

A-List
The best buy in its category right now. The product will also feature on our A-List, starting on p14. It's updated each month.

Labs Winner
Each month we run a group test, or Labs. This product has managed to beat all others to top position.

Tinyurl.com links

Throughout the magazine you'll see tinyurl.com shortcuts. Enter these into the address bar of your browser and it will take you to a particular page, which will either be too long or awkward for us to publish or will take you to the precise shop from which to buy. If it's Amazon, note that we may have an affiliate deal in place so we will receive a commission from each sale. This will never affect our verdict of a product, and if another reputable vendor is selling the product cheaper then we will use that instead.

Prices will vary

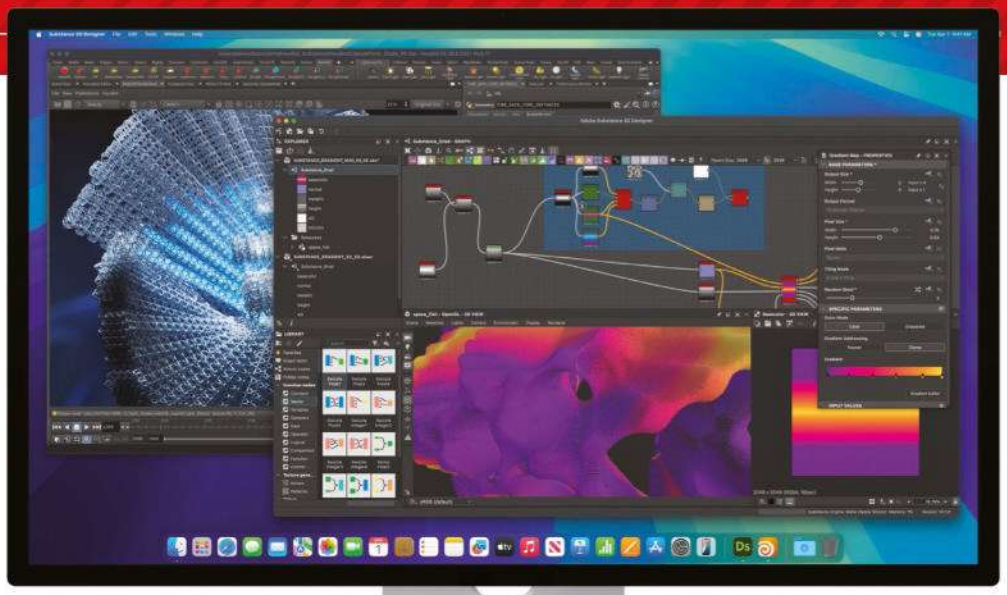
Prices we publish are correct on the day we publish, but we often see prices change, especially on sites such as Amazon. However, we do work with British PC retailers to ensure the prices we quote for their systems are correct. If the price isn't being honoured, contact us via letters@pcpro.co.uk.

Apple Mac Studio M4 Max and M3 Ultra

Macs are rarely bargains, but the Studio delivers striking levels of performance in M4 Max and M3 Ultra form

SCORE ★★★★½

PRICE M4 Max from £1,749 (£2,099 inc VAT); M3 Ultra from £3,499 (£4,199 inc VAT) from apple.com



ABOVE The Studio has the same boxy design as before, but now packs a greater punch

Apple's latest Mac Studio models look just like previous versions, but they're built on newer and even more powerful chips. Depending on your needs you can opt for either the M4 Max or the mightiest processor Apple has ever made, the M3 Ultra. As usual, the target market is creative professionals such as photographers and video editors, while the extra power of the M3 Ultra makes it suited to more demanding tasks such as AI, engineering and scientific research.

Pick and choose

The M4 Max and M3 Ultra systems have the same boxy design as previous models. They also offer all the same physical connectors, including four rear-facing Thunderbolt 5 ports, twin USB-A sockets and a 10Gbits/sec Ethernet port. The only difference concerns the pair of Type-C sockets that sit at the front, next to the SDXC slot: on the M4 Max these are limited to 10Gbits/sec USB, while on the M3 Ultra they support Thunderbolt 5 at speeds up to 120Gbits/sec.

Both models also offer Bluetooth 5.3 and Wi-Fi 6E. Wi-Fi 7 is becoming more commonplace on high-end routers and laptops, but Apple hasn't yet made that shift on its computers.

The M4 Max is a known quantity, as we've already seen it on the latest MacBook Pro laptops. The base Mac Studio uses a version of this chip with 14 CPU cores and a 32-core GPU, along with 36GB of unified memory and a 512GB SSD, and costs a pretty reasonable £2,099 inc VAT. There's also a more powerful M4 Max model, which has 16 CPU cores and 40 GPU cores; this is the version I tested, and my unit was also boosted with 128GB of unified memory and a 1TB SSD. This is much more of a "workstation" specification, but the upgrades push the price up to £3,799.

Fish for chips

For the most heavyweight roles, the new M3 Ultra comes into play. It may seem strange that Apple's top-tier chip is based on last year's core design, but the firm's position is that not every generation of chip needs an "Ultra" variant – and this one still packs in a huge amount of power, as in effect it's two M3 Max chips joined together. As well as doubling the core count and memory capacity, this gives it greater memory bandwidth, enabling it to tear through demanding tasks.

As with the M4 Max, you can choose between two variants of the M3 Ultra: one with 28 CPU and 60 GPU cores, and a top-end specification with 32 CPU and 80 GPU cores. The cheapest Mac Studio with an Ultra processor costs £4,199 inc VAT, including 96GB of RAM and a 1TB SSD, while my review unit came with the more powerful chip, 256GB of unified memory and a 4TB SSD, raising the retail price to an eye-watering £8,299. If you have very deep pockets you can go all the way up to 512GB of RAM and a vast 16TB SSD, for a total cost of £14,299.

As with most Macs, the RAM and SSD are fixed at the point of purchase. In other words, you'll need to factor in your future needs when specifying the memory, and any extra storage will need to be attached externally. There are third parties offering unofficial SSD upgrade cards, but these aren't endorsed or supported by Apple, so professionals will probably want to steer clear. Remember too that, as with the Mac mini, you don't get a keyboard or mouse in the box, so you'll also need to budget for those.

PC PRO RECOMMENDED

"The extra power of the M3 Ultra makes it suited to demanding tasks such as AI, engineering and scientific research"

BELOW Apple's most powerful computer is squarely aimed at creative professionals

Workstation-like power

We benchmarked the new Mac Studio models alongside a pair of PC workstations, one based on the AMD Threadripper Pro 5975WX and the other using Intel's Xeon w9-3495X. The former is a 64-core chip, while the latter has 56 cores, and both cost upwards of £5,000 for the processor alone, making the Mac Studio start to look like pretty decent value.

We began our benchmarks with the Geekbench 6 CPU test, where the M3 Ultra kicked off with an outstanding single-core score of 3,349, putting it well beyond the AMD and Intel systems. Perhaps surprisingly, the cheaper M4 Max did even better, scoring 4,113. This is presumably because the newer chip runs at a

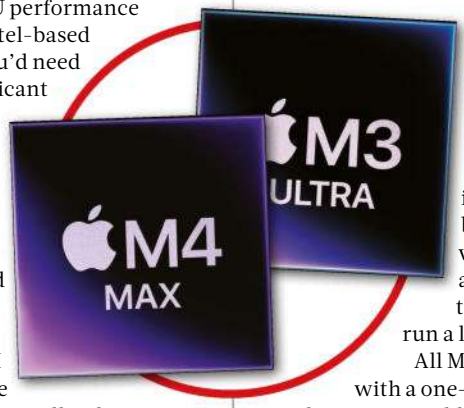
higher clock speed of 4.5GHz, compared to the M3 Ultra's 4.05GHz.

Multicore performance was also unexpectedly close. Here the M3 Ultra scored 27,929, while the M4 Max almost matched it with 26,966, despite having only half as many cores. Clearly not all workloads get a significant benefit from the doubled-up Ultra architecture.

Differences became apparent elsewhere, however. The Handbrake test showed the value of the M3 Ultra's extra bandwidth, with our 4K video file transcoding to 1080p in only 1min 16secs, while the M4 took 1min 56secs and the PC chips lagged well behind.

Apple's chips both struggled – comparatively speaking – in the Blender 4 test. The M3 Ultra put up a valiant fight in the Monster CPU test, averaging a strong 394 samples per second, but it was no match for the AMD and Intel chips, which managed 485 and 447 respectively, while the M4 Max sat further behind at 241. It was a similar story in the Junkshop CPU test, where neither Studio model could keep up with AMD or Intel.

Still, switching to GPU testing saw Apple leap back into the lead, absolutely destroying the competition. If you wanted comparable GPU performance on an AMD or Intel-based workstation, you'd need to spend a significant extra sum on an external graphics card. It's also worth mentioning that the new Mac Studios achieved all of these feats silently: even under full load, I couldn't hear the dual internal fans at all unless I intentionally pressed my ear right up against the exhaust vent.



The extras

The new Mac Studio models ship with macOS Sequoia 15 – the latest version at the time of release. This doesn't look or feel much different to previous versions, but it does introduce various Apple Intelligence features, along with Continuity updates that let you view and control your iPhone from your macOS desktop, and drag and drop files and media between your Mac and iPhone. Although we're now more than four years into the Apple silicon era, Sequoia also still includes the Rosetta 2 translation layer for those who need to run legacy x86 software; this isn't installed by default, but will download automatically the first time you run a legacy app.

All Mac Studios ship with a one-year warranty, but you can add three years of AppleCare+ coverage (Apple's extended warranty) for £169. In my opinion, though, that seems a little unnecessary for a desktop system.

Bottom line

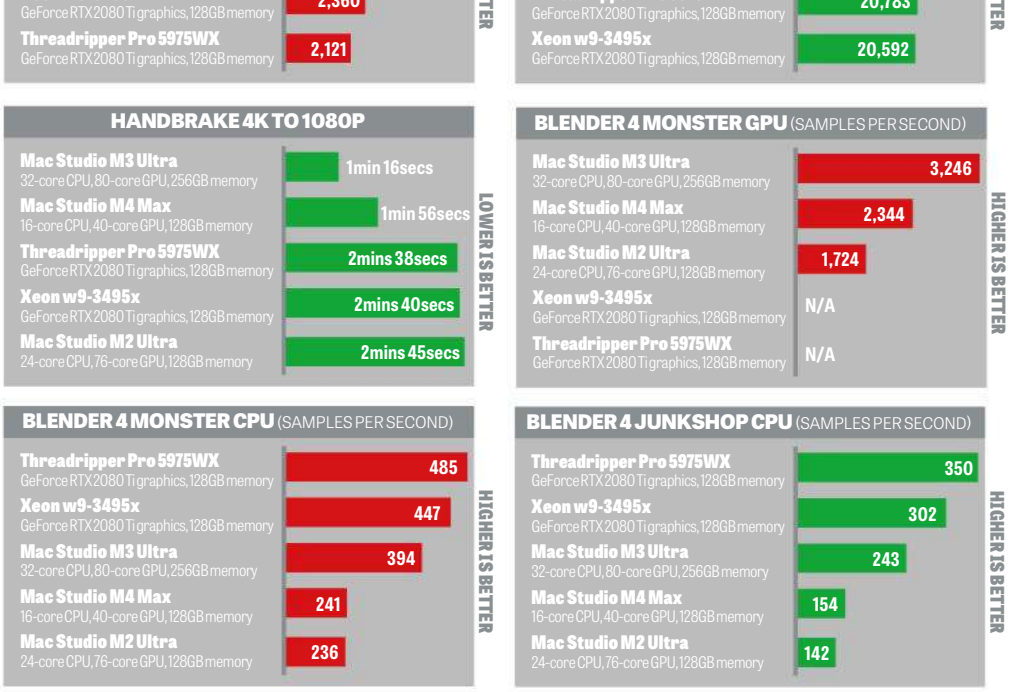
The Mac Studio is an incredible computer. For less than the cost of a bare Threadripper or Xeon processor you get a fully functioning macOS machine with enormous horsepower. The downside is that once you've chosen your specification there's no way to subsequently extend the memory, and maxing out the RAM at the point of purchase is very expensive compared to upgrading a standard workstation PC.

Still, if you're in the Apple camp, you'll have made your peace with the non-upgradable design. And what you get for your money is a superb workstation, compact and user-friendly, yet bristling with high-end connectivity and packed with raw power. **BRANDON HILL**

"What you get is a superb workstation, compact and user-friendly, yet bristling with high-end connectivity and packed with raw power"

LEFT The M4 Max and M3 Ultra are among the most powerful chips you can buy

BELOW There are four Thunderbolt 5 ports, twin USB-A sockets and a 10GbE port



SPECIFICATIONS

M4 Max: 14-core (10 performance cores, 4 efficiency cores) Apple M4 Max • 32-core/40-core GPU • 16-core Neural Engine • 36GB/48GB/64GB/128GB unified memory • 512GB/1TB/2TB/4TB/8TB M.2 PCIe Gen 4 SSD • 2 x USB-C 3.2 Gen 2 (front) • 2.7kg.

M3 Ultra: 28-core (20 performance cores, 8 efficiency cores) Apple M3 Ultra • 60-core/80-core GPU • 32-core Neural Engine • 96GB/256GB/512GB unified memory • 1TB/2TB/4TB/8TB/16TB M.2 PCIe Gen 4 SSD • 2 x Thunderbolt 5/USB-C 4 (front) • 3.6kg.

Shared: HDMI 2.1 • 4 x Thunderbolt 5/USB-C 4 • 2 x USB-A 3.2 Gen 1 • 10GbE • 3.5mm headphone jack • SDXC card slot • Wi-Fi 6E • Bluetooth 5.3 • macOS Sequoia • 197 x 197 x 95mm (WDH) • 1yr RTB warranty

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4TB SSD
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LN148982

AMD Ryzen Threadripper 7960X
128GB DDR5
48GB PNY NVIDIA RTX PRO 5000
2TB SSD
Microsoft Windows 11 Pro
3 Year Premium Warranty

3XS GWP-A1-C24
LN148980

Intel Core Ultra 9 285K
96GB DDR5
32GB PNY NVIDIA RTX Pro 4500
2TB SSD
Microsoft Windows 11 Pro
3 Year Premium Warranty

3XS GW-A1-R24
LN148949

AMD Ryzen 9 9900X
64GB DDR5
24GB PNY NVIDIA RTX Pro 4000
2TB SSD
Microsoft Windows 11 Pro
3 Year Premium Warranty

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Wired2Fire R7X3D 9070 XT Beast

A strong debut for AMD's Radeon RX 9070 XT, and if you have space to house it this is a striking choice

SCORE ★★★★★

PRICE £1,917 (£2,300 inc VAT)
from wired2fire.co.uk

ABOVE Beast of a thing: this imposing PC more than lives up to its name

If you read our review of AMD's Radeon RX 9070 XT graphics card (*see issue 368, p70*) then you'll know that Nvidia finally has serious competition at the high end. But it needs the right processing partner, which is where AMD's Ryzen 7 9800X3D comes in. While the Ryzen 7 7800X3D was great for gaming, it couldn't be easily overclocked; the Ryzen 7 9800X3D, on the other hand, is effectively AMD's unlocked Ryzen 7 9800X with extra cache.

Such a powerful pairing needs a suitable base, and British PC manufacturer Wired2Fire doesn't hold back. As its name gives away, the Gigabyte X870 Eagle WiFi 7 uses AMD's top-end chipset – and that means all the mod cons. PCIe Gen 5 support for one of its three M.2 slots, 2.5GbE and Wi-Fi 7 networking, plus dual USB-C 4 ports. Here, Gigabyte's EZ-Latch technology ensures that removing the giant GPU, M.2 storage and any PCIe expansion cards you may add is easy. A 2TB Kingston Fury Renegade Gen 4 card sits in the Gen 5 M.2 slot but is still supremely fast: 7,367MB/sec reads, 6,832MB/sec writes. You can also add more storage via two easy-access 2.5in/3.5in bays at the rear of the case.

LEFT The big windows are easily opened and make upgrades easy

Two PCIe x16 slots (Gen 3) sit at the bottom of the board, and it couldn't be easier to access them thanks to the Gamdias Neso P1 Pro chassis. It's huge, measuring 310mm wide and a little under 500mm tall and deep. But you can switch orientation from "tower" and lay it on its back if that better suits your location, and as both the front and the side windows swing open at the press of a latch it doesn't matter which orientation you choose.

This also means the inside lies wide open for upgrades, so it's good that Wired2Fire has paid such attention to the cabling and the RGB fans. The three Gamdias fans at the front right have a striking hexagonal design, while the three top-mounted fans, part of the Arctic Cooling liquid cooler, are conventional round designs but bang out the colour. There are three more sources of RGB light: one on top of the liquid cooler, two atop the pair of 16GB Kingston Fury Beast RGB DDR5-6000 DIMMs (two sockets lie empty if you want more than 32GB), and a discreet trio of LEDs on the Gigabyte graphics card.

Despite its name and size, Wired2Fire supplied the Beast with fan profiles in a room-friendly setup where it whispers along until pushed. Even then, they rarely become loud. It's a speedy machine despite its quietness, with 13,904 in Cinebench 2024's multicore section and smooth frame rates in games at 4K. At maximum graphics settings, it averaged 125fps in *Shadow of the Tomb Raider*, 140fps in *Dirt 5*, 107fps in *Borderlands 3* and 81fps in *Cyberpunk 2077*.

That compares well to the RTX 5070-powered CyberPowerPC Infinity Z890 Air I reviewed last month (*see issue 368, p61*), which returned 151fps in *Shadow of the Tomb Raider* (one game where the RX 9070 XT struggles), 104fps in *Dirt 5*, 86fps in *Borderlands 3* and 66fps in *Cyberpunk 2077*. It also held its own against the PCSpecialist opposite, which includes a GeForce RTX 5070 Ti and averaged 187fps, 133fps, 109fps and 70fps. Even when I activated ray tracing in *Cyberpunk*, the Beast kept its nose ahead of the PCSpecialist, with 76fps versus 74fps.

There are still areas where Nvidia wins, most notably any application that takes advantage of CUDA cores; in Blender, for example, the RTX 5070 Ti is almost twice as fast as the RX 9070 XT. If your workflows don't rely on CUDA, however, this marks an excellent time to jump ship from Nvidia to AMD.

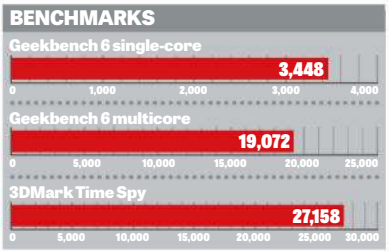
"It's a fast all-round system: the Ryzen 7 9800X3D won't disappoint thanks to its eight high-performance Zen 5 cores"

Admittedly, this level of performance doesn't come cheap. The Beast is £399 more expensive than the CyberPowerPC Infinity Z890 Air, which is far more compact and a superb performer in 1440p games.

But the Wired2Fire goes one step further, returning around 200fps at 1440p and slick frame rates at 4K. It's also a fast all-round system: the Ryzen 7 9800X3D won't disappoint thanks to its eight high-performance Zen 5 cores. Finally, we come to that top-quality chassis with such easy upgrade routes, with an 850W PSU in place (enough for an RTX 5080 card if you decide to go the Nvidia route). But whatever you choose to do in the future, it couldn't be easier to work inside this case. **TIM DANTON**

BELOW The three RGB fans on the right are strikingly designed

BENCHMARKS



SPECIFICATIONS

8-core/16-thread AMD Ryzen 7 9800X3D processor • Gigabyte X870 Eagle WiFi 7 motherboard • 32GB Kingston Fury Beast RGB DDR5-6000 RAM • 16GB AMD Radeon RX 9070 XT graphics • Arctic Cooling Freezer III 360mm RGB AIO liquid cooler • 2TB Kingston Fury PCIe Gen 4 SSD • Gamdias Neso P1 Pro chassis • 850W Phanteks AMP GH PSU • Windows 11 Home • 310 x 490 x 495mm (WDH) • 5yr warranty (2yr C&R, 3yr parts and labour) • power: 91W idle, 616W peak

PCSpecialist Eclipse R70i Lumin

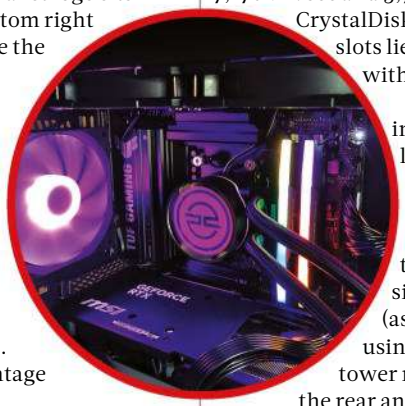
If you want a speedy gaming PC in a hurry, this is a well-built choice that will keep you happy for years

SCORE ★★★★☆

PRICE £1,958 (£2,349 inc VAT) from pcspecialist.co.uk

Wakefield-based PCSpecialist has earned its reputation for bespoke PCs, but it also offers a wide range of next-day PCs. If it's in stock, and you order in time for PCSpecialist to book a delivery slot with DPD, it will be with you the next day. Here, it sent us the latest addition to its next-day range based on its own PCS Lumin ARGB Mid-Tower chassis.

By a complete coincidence, I can unmask this chassis as a custom version of the Gamdias Neso P1 Pro – because that's what the Wired2Fire opposite uses and the two are identical. Except for branding, that is, because the PCSpecialist logo sits discreetly at the bottom right of this chassis, while the tag you pull to open the main window is also branded.



This is excellent news for those who like to upgrade their systems, or gaze at them in awe, because the Neso P1 Pro is an outstanding chassis. It also has the advantage that it can sit in two orientations: tower, as shown, or on its side. On flipping both windows open, keen upgraders won't be able to resist a beatific smile spreading as they see the expanse of motherboard sitting ready for them.

Still, I would remove the graphics card before attempting to fill either of the two available PCIe expansion slots. The top-most PCIe Gen 4 x1 slot is blocked by the GPU whatever you do, but another sits at the bottom of the Asus TUF Gaming B850-Plus motherboard along with an x16 slot (operating at a maximum of x4 speeds) so there's no shortage of options. Likewise if you want to add to the supplied 2TB Samsung 990 Evo Plus Gen 4 offering, which is predictably fast with sequential read and write speeds of 7,170MB/sec and 5,799MB/sec in CrystalDiskMark 8. Two M.2 slots lie in wait, complete with a heatsink cover.

ABOVE **The Eclipse is a pre-built PC available with next-day delivery**

There's no point in buying a chassis like this and holding back on RGB lighting, with six fans adding to the parade. Three sit at the front right (assuming you're using the Eclipse in tower mode), one sits at the rear and the further two are part of the PCS FrostFlow liquid cooler, which has an LCD screen that you can customise with your own graphics. The final splash of colour comes from a pair of Corsair Vengeance DIMMs, both rated at DDR5-6000 speeds.

"Upgraders won't be able to resist a beatific smile spreading as they see the expanse of motherboard sitting ready for them"

LEFT **Nvidia's RTX 5070 Ti provides speedy gaming performance**

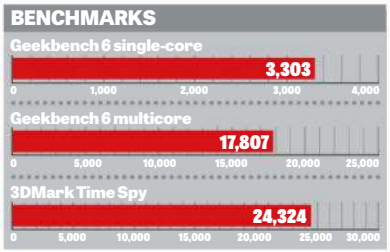
As with most recent PCs I've tested, all these fans don't mean you have to put up with annoying fan noise. The Eclipse is a perfectly polite desk companion, with the fans barely audible until you throw a demanding task at it. For instance, while scoring 1,295 in Cinebench 2024 I had to live with the fans ramping up to mid-range speeds (still not annoying, but very much there). This was around 100 points slower than the Wired2Fire, which includes the same Ryzen 7 9800X3D processor, which is perhaps a reflection of the superior X870 chipset in the other PC's motherboard (the B850 here is a mainstream choice). It was also quicker in Geekbench 6's multicore test, so this wasn't a one-off.

Switch to gaming and Wired2Fire's Radeon RX 9070 XT graphics give it the edge in 3DMark Time Spy (and other 3DMark tests) and two of my four test games: in *Shadow of the Tomb Raider* the Eclipse returned 187fps at 4K Highest compared to 125fps for its rival, while it averaged 109fps in *Borderland 3* (Ultra settings) to 107fps. In 4K and with top settings, the Eclipse averaged 133fps in *Dirt 5* (versus 140fps for the Beast) and 70fps in *Cyberpunk 2077* (versus 81fps).

Nvidia's RTX 50 series cards hold advantages over AMD's RX 70 series. For gamers, that comes down to the promise of Frame Generation and DLSS 4, which could be the difference between your favourite game being smoothly playable at 4K or not. As the modern saying goes, do your research. And there's also the CUDA factor for creative professionals, with the established platform providing a boost in, for example, both Blender and Adobe Premiere Pro.

BELOW **The brightly lit chassis is perfect for upgraders**

If you're of the jam tomorrow persuasion – or you simply prefer Nvidia's way of doing things – then you should choose the PCSpecialist Eclipse R70i Lumin. Not least as it's a pre-built system so should be available for next day delivery, while you may have to wait a couple of weeks for the Beast. What's more, PCSpecialist always challenges for awards in our annual customer satisfaction survey. **TIM DANTON**

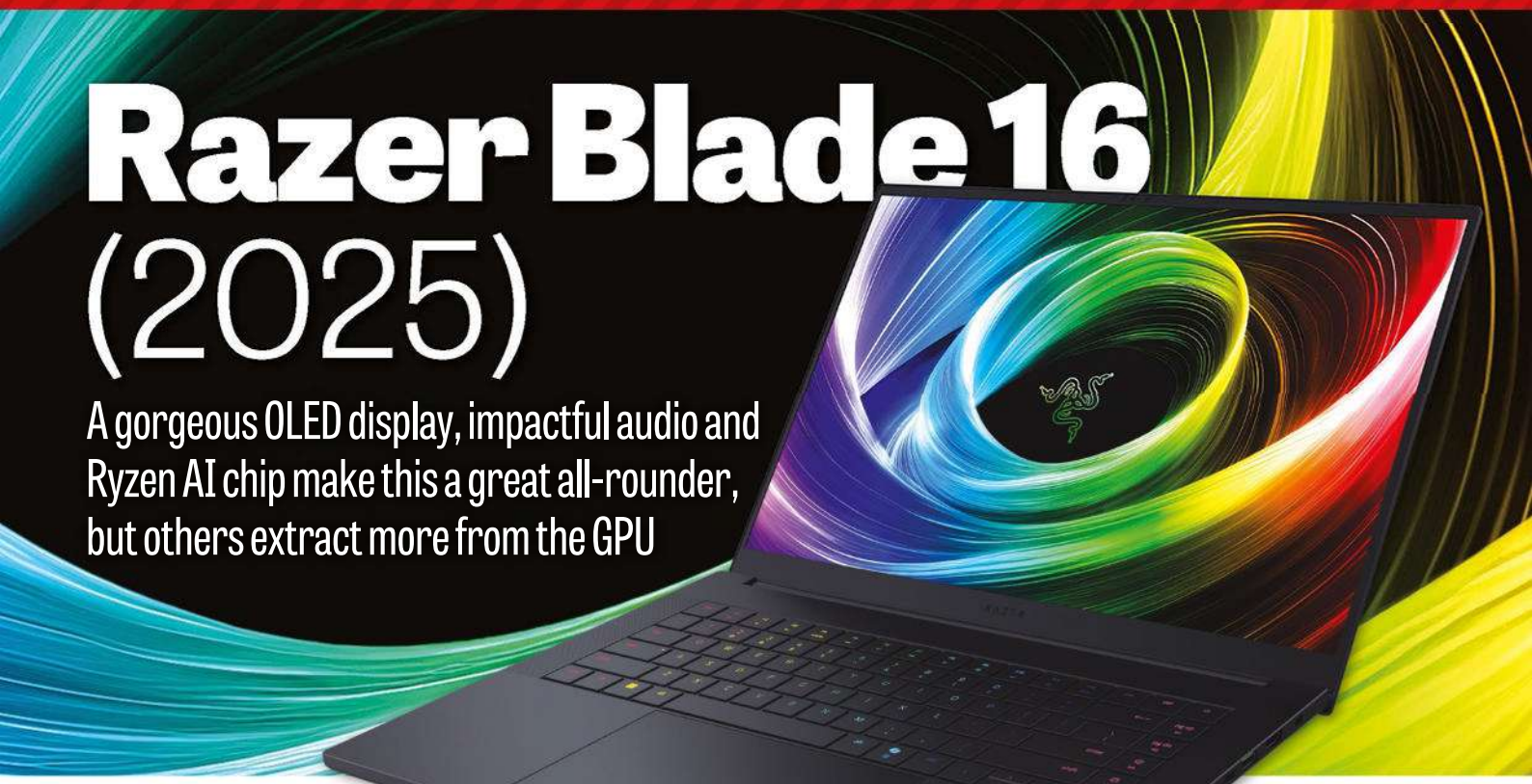


SPECIFICATIONS

8-core/16-thread AMD Ryzen 7 9800X3D processor • Asus TUF Gaming B850-Plus WiFi motherboard • 32GB Corsair Vengeance DDR5-6000 RAM • 16GB Nvidia GeForce RTX 5070 Ti graphics • PCS FrostFlow 240 ARGB liquid cooler • 2TB Samsung 990 Evo Plus M.2 PCIe Gen4 SSD • PCS Lumin ARGB Mid-Tower Case • 750W Corsair RM PSU • Windows 11 Home • 310 x 490 x 495mm (WDH) • 3yr warranty (6 month C&R, 1yr RTB parts & labour, 2yr labour only) • power: 93W idle, 572W peak

Razer Blade 16 (2025)

A gorgeous OLED display, impactful audio and Ryzen AI chip make this a great all-rounder, but others extract more from the GPU



SCORE ★★★★☆

PRICE As reviewed, £3,250 (£3,900 inc VAT) from razer.com

The moment I saw the new Blade 16 at CES in January, I had concerns. Such a slim design, far thinner than the 2024 model (*see issue 359, p60*), surely came with a trade-off in performance? Another question mark was over Razer's choice of a non-gaming CPU in the AMD Ryzen AI 300 series; last year's model used Intel's non-AI but gaming-friendly Core i9-14900HX.

Fast-forward to this laptop arriving in our labs configured with the top-of-the-range RTX 5090, which is reflected in its £3,900 price. The base model of the new Blade 16 costs £2,700, which buys you an AMD Ryzen AI 9 365 processor, 12GB GeForce RTX 5070 Ti graphics, a 1TB SSD, 32GB of RAM and a 16in, 2,560 x 1,600, 240Hz OLED display (as used in all the models).

You can upgrade to an RTX 5080 for £400, with further options to double the RAM and the storage, or even opt for a 4TB setup based on two 2TB SSDs. The most expensive option ships with a Ryzen AI 9 HX 370 processor, 64GB of RAM and 4TB of storage for £4,300. My test unit had that spec but with a single 2TB SSD.

Gaming ups and downs

So, was I right to be concerned? There was only one way to find out, and that was to put this laptop through its paces, then compare it to the previous Razer Blade 16 and two other RTX 50 series laptops we've already tested.

To say performance was mixed is an understatement. While the 2025 Razer Blade 16 often outperforms its predecessor, on occasion it lost out to last year's i9-14900HX and 4090 model. *Assassin's Creed: Mirage* and *Far Cry 6* were the two biggest outliers, with the 4090 averaging up to 15fps higher than the 5090.

However, it isn't only the RTX 4090 that outpaces the Blade 16's 5090 performance. The Gigabyte Aorus Master 16 features an RTX 5080 but still outperformed the Blade by up to 25fps in those two games. I should mention, however, that those tests are at 1080p, at which point the CPU becomes a limiting factor.

That doesn't mean gaming on the Razer Blade 16 (2025) is bad. Just about every game we tested hit playable speeds, with only new intensive titles such as *Assassin's Creed: Shadows* and *Black Myth: Wukong* failing to pass the 60fps mark at their highest graphics presets. And it's worth noting that here, where the CPU isn't limiting frame rates, the RTX 5090 in the Blade 16 pushed it to 58fps in *Black Myth: Wukong* while the Gigabyte could only manage 52fps. The GPU's potential was also obvious from our 3DMark tests, where the Razer topped the tables, and don't forget that software upscaling using DLSS 4 and frame generation can get even more performance out of the RTX 50 cards in games that take advantage.

ABOVE The Razer Blade 16 is an attractive laptop with a dazzling display

"The result is a stunning gaming experience. I had to force myself to actually play games on the Blade 16 rather than just watch them"

Cores versus AI

It's a less nuanced scene in Geekbench 6, an out-and-out CPU test. Here, the 2024 Blade 16 outperformed its successor in the multicore section by 9%, while the Aorus and HP Omen Max 16 – both featuring Intel's 24-core Ultra 9 275HX chip – beat it by a full 20%.

One plus side of AMD's AI-focused CPU is that it includes an NPU rated at 50 TOPS, surpassing Microsoft's Copilot+ PC requirements. This means you can already enjoy Live Captions and Cocreate in Microsoft Paint, plus advanced video effects, but perhaps more importantly Recall when it finally lands. Plus, its CPU, NPU and GPU combo is powerful enough to run whatever large language model (LLM) you want.

The most useful AI tool on the Blade 16 is part of Razer Synapse 4: this AI-powered hardware configuration tool can even optimise your CPU voltage. Synapse 4 also has macro features that allow you to simplify complex key inputs for recurring tasks. This is handy for

BELOW The ultra-slim chassis weighs just 2.1kg and includes a full array of ports

gamers who do a lot of in-game crafting, but anyone can take advantage.

Sleek design

As mentioned, one of the biggest changes is this year's ultra-slim chassis. Where the 2024 model weighed 2.5kg and measured 22mm thick (at its thinnest point), the 2025 edition slims down to 2.1kg and 15mm. Both the Gigabyte and HP laptops are significantly heavier, too.

So the Blade 16 is more attractive than ever, helped by its classy matte black aluminium chassis (fingerprint smudges sadly remain an issue). The lid features the familiar Razer snake logo, but this time the insert lights up in electric Razer green, adding flare compared to last year's model.

Despite its slim design – I won't use the word compact, as the Blade 16 is 355mm wide as per last year – Razer packs in a full array of ports. That includes two USB-C 4 ports, a trio of USB-A 3.2 Gen 2 ports, HDMI 2.1, a fast UHS-II microSD card reader and an audio combo jack. Unlike some gaming laptops, Razer also squeezes a 1080p IR webcam into the bezel, certified for Windows Hello. Colours are accurate but it isn't as detailed as the best laptop webcams.

OLED colour splash

Then we come to the dazzling 2,560 x 1,600 OLED panel. OLED screens tend to be vivid, but this covers 145% of the DCI-P3 gamut, so 45% more colours than the palette favoured by filmmakers. The result is a stunning gaming experience. I had to force myself to actually play games on the Blade 16 rather than just watch them.

One downside of OLED displays is often low brightness, but the Razer panel peaks at 372cd/m² with regular content and 567cd/m² in HDR films and games. It's still not the best choice for working in the sun due to its glossy finish, but the panel is bright enough to cut through most conditions.

I was also impressed by the powerful THX-tuned front-facing speakers. While running around in *Monster Hunter*, the top volume of the Blade 16 drowned out the blaring fan noise, while the Arkveld theme in particular was an auditory feast thanks to the Blade 16's powerful woofers pumping up the bass in contrast to the sharp high-notes.

Despite its slimmed-down design the Blade 16 keeps Razer's signature keyboard deck. Each key is nicely spaced apart, so you don't need to second-guess your hand position, while the Shift and Control keys are within easy reach. A 1.5mm key travel, coupled with a tactile feel on each depression, provides a satisfying typing experience, whether you're using the Blade 16 for gaming or typing up a 5,000-word report. I also love the oversized Precision glass touchpad, with a silky feel matched with a concrete clicking action.

ABOVE Razer's keyboard is a joy to use, whether you're gaming or typing

Bottom line

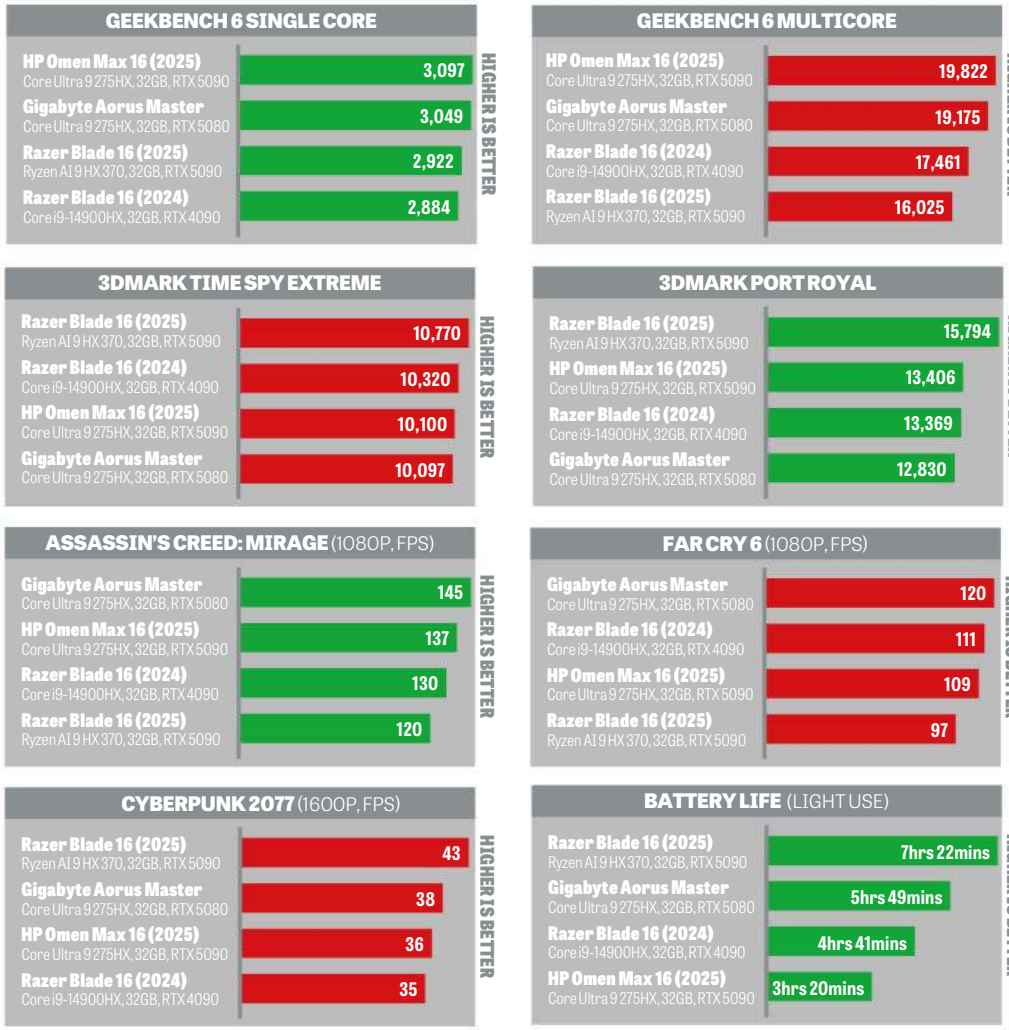
Gaming laptop battery life is traditionally poor, so the Blade 16's result of 7hrs 22mins in our light-use battery test is impressive. I also put Nvidia's new Battery Boost tech to the test. Nvidia claims this will get you up to 40% better battery life while gaming. I can't say I saw a 40% jump, but I did enjoy a mostly smooth two-hour gaming experience using the Blade 16 unplugged. However, and despite a revamped cooling chamber, the laptop gets hot under pressure, whether plugged in or not.

So, is the new Razer Blade 16 hot or not? In some ways, yes, definitely. It features a stunning OLED display, Razer's superb build quality, several hours of non-gaming battery life and more ports than most people will ever need. The improved keyboard and audio are also worthy upgrades over the 2024 Razer Blade 16. And it's incredibly portable, too.

Whether or not you should buy the 2025 model really depends on your priorities. If you want a desktop replacement with blazingly fast CPU and GPU performance, hold out for the Razer Blade 18 or one of the other upcoming RTX 50-series laptops with an Intel Arrow Lake or AMD Fire Range gaming CPU. Or opt for the 4090 version of the Blade 16 while it's still available. But if you prefer portability, battery life and gorgeous OLED displays, this year's Blade 16 is a great option. **MADELINE RICCHIUTO**

SPECIFICATIONS

12-core/24-thread AMD Ryzen AI 9 HX 370 processor • 24GB Nvidia GeForce RTX 5090 graphics • 32GB LPDDR5X-8000 RAM • 16in non-touch, OLED display, 240Hz, 2,560 x 1,600 resolution • 2TB M.2 Gen4 SSD • Wi-Fi 7 • Bluetooth 5.4 • 1080p IR webcam • 2 x USB-C 4 • 3 x USB-A 3.2 Gen 2 • HDMI 2.1 • UHS-II microSD card reader • 3.5mm combo jack • 90Wh battery • Windows 11 Home • 355 x 251 x 14.9-17.4mm (WDH) • 2.1kg • 1yr limited warranty


GEEKBENCH 6 SINGLE CORE
HP Omen Max 16 (2025) Core Ultra 9 275HX, 32GB, RTX 5090 3,097
Gigabyte Aorus Master Core Ultra 9 275HX, 32GB, RTX 5080 3,049
Razer Blade 16 (2025) Ryzen AI 9 HX 370, 32GB, RTX 5090 2,922
Razer Blade 16 (2024) Core i9-14900HX, 32GB, RTX 4090 2,884
HIGHER IS BETTER
GEEKBENCH 6 MULTICORE
HP Omen Max 16 (2025) Core Ultra 9 275HX, 32GB, RTX 5090 19,822
Gigabyte Aorus Master Core Ultra 9 275HX, 32GB, RTX 5080 19,175
Razer Blade 16 (2024) Core i9-14900HX, 32GB, RTX 4090 17,461
Razer Blade 16 (2025) Ryzen AI 9 HX 370, 32GB, RTX 5090 16,025
HIGHER IS BETTER
3DMARK TIME SPY EXTREME
Razer Blade 16 (2025) Ryzen AI 9 HX 370, 32GB, RTX 5090 10,770
Razer Blade 16 (2024) Core i9-14900HX, 32GB, RTX 4090 10,320
HP Omen Max 16 (2025) Core Ultra 9 275HX, 32GB, RTX 5090 10,100
Gigabyte Aorus Master Core Ultra 9 275HX, 32GB, RTX 5080 10,097
HIGHER IS BETTER
3DMARK PORT ROYAL
Razer Blade 16 (2025) Ryzen AI 9 HX 370, 32GB, RTX 5090 15,794
HP Omen Max 16 (2025) Core Ultra 9 275HX, 32GB, RTX 5090 13,406
Razer Blade 16 (2024) Core i9-14900HX, 32GB, RTX 4090 13,369
Gigabyte Aorus Master Core Ultra 9 275HX, 32GB, RTX 5080 12,830
HIGHER IS BETTER
ASSASSIN'S CREED: MIRAGE (1080P, FPS)
Gigabyte Aorus Master Core Ultra 9 275HX, 32GB, RTX 5080 145
HP Omen Max 16 (2025) Core Ultra 9 275HX, 32GB, RTX 5090 137
Razer Blade 16 (2024) Core i9-14900HX, 32GB, RTX 4090 130
Razer Blade 16 (2025) Ryzen AI 9 HX 370, 32GB, RTX 5090 120
HIGHER IS BETTER
FAR CRY 6 (1080P, FPS)
Gigabyte Aorus Master Core Ultra 9 275HX, 32GB, RTX 5080 120
Razer Blade 16 (2024) Core i9-14900HX, 32GB, RTX 4090 111
HP Omen Max 16 (2025) Core Ultra 9 275HX, 32GB, RTX 5090 109
Razer Blade 16 (2025) Ryzen AI 9 HX 370, 32GB, RTX 5090 97
HIGHER IS BETTER
CYBERPUNK 2077 (1600P, FPS)
Razer Blade 16 (2025) Ryzen AI 9 HX 370, 32GB, RTX 5090 43
Gigabyte Aorus Master Core Ultra 9 275HX, 32GB, RTX 5080 38
HP Omen Max 16 (2025) Core Ultra 9 275HX, 32GB, RTX 5090 36
Razer Blade 16 (2024) Core i9-14900HX, 32GB, RTX 4090 35
HIGHER IS BETTER
BATTERY LIFE (LIGHT USE)
Razer Blade 16 (2025) Ryzen AI 9 HX 370, 32GB, RTX 5090 7hrs 22mins
Gigabyte Aorus Master Core Ultra 9 275HX, 32GB, RTX 5080 5hrs 49mins
Razer Blade 16 (2024) Core i9-14900HX, 32GB, RTX 4090 4hrs 41mins
HP Omen Max 16 (2025) Core Ultra 9 275HX, 32GB, RTX 5090 3hrs 20mins
HIGHER IS BETTER

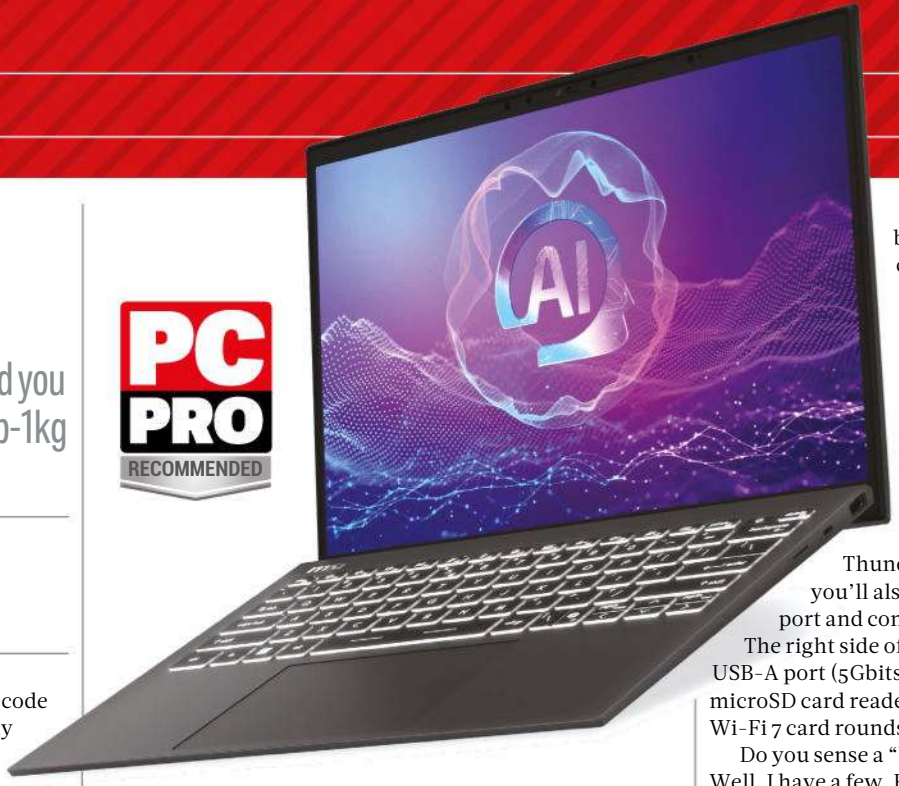
MSI Prestige 13 AI+ Evo A2VM

An extremely powerful system for the price, and you can't argue about its sub-1kg weight or battery life

PC PRO RECOMMENDED

SCORE ★★★★½

PRICE £833 (£999 inc VAT)
from currys.co.uk



Our first job is surely to decode this laptop's prodigiously long name. Prestige indicates that it's part of Taiwanese manufacturer MSI's business and productivity range; 13 the size of its screen (13.3in to be precise); AI+ that it meets Microsoft's Copilot+ PC criteria; Evo that it passes Intel's Evo checklist; and A2VM… well, life has to have some secrets.

I can reveal that this is an incredibly light laptop. MSI states 990g but it tipped my scales at 967g, and the usual cliché applies: I genuinely didn't notice this in my rucksack. MSI achieves this feat via a magnesium-aluminium chassis, and while there's flex in the lid (not a bad thing as this helps to absorb impacts), the Prestige 13 will surely maintain its professional aura for far longer than the one-year warranty suggests. You can extend this by three months if you register, which is made easier thanks a link in MSI's Center 5 software. Sadly, there's no way to upgrade the warranty from here.

I recommend you have a good hunt around MSI's app as it's where you'll find settings such as switching on the AI engine to (supposedly) speed up the system based on your behaviour. I stuck with the Extreme Performance setting in my tests, as it makes sense to extract the most possible speed when buying a Core 9 processor. The laptop proved a great performer too, reaching almost 11,000 in Geekbench 6's multicore test, over 600 in Cinebench 2024 and a tidy 9,275 in the Digital Content Creation portion of PCMark 10. The 288V chip may only have eight cores, but thanks to 32GB of RAM and judicious use of the fans MSI extracts every ounce of power.

Intel's ever-impressive Arc 140V graphics pushed the Prestige 13 to 55fps in *Dirt 5* and 50fps in *Shadow of the Tomb Raider*. Both of those results were with Low settings at 1080p, but switch to the panel's native resolution of 2,880 x 1,800 and things remain playable if you drop down to Lowest settings: those games averaged 40fps and 41fps respectively.

The OLED screen looks fantastic in games and films. It covers the whole of the DCI-P3 space, and beyond, while its average Delta E of 0.32 is excellent. The screen has a yellow tinge at lower brightnesses, but push it anywhere close to its 394cd/m² peak (plenty for an OLED panel thanks to its perfect contrast) and whites are excellent.

Often an OLED panel destroys battery life, but not here. Our light-use tests are modest, with the screen set at 150cd/m², but even so the Prestige 13's 17hrs 22mins is terrific. Anecdotally, pushing the screen to full brightness and working on it for an hour saw the battery gauge drop by 8%, so I'm confident it will last for the toughest of full working days.

Nor does MSI put all its eggs into the USB-C basket. Two such ports sit on the left-hand side, both supporting Thunderbolt 4, but you'll also find an HDMI 2.1 port and combo jack there. The right side offers a still useful USB-A port (5Gbits/sec) plus a microSD card reader. An Intel Killer Wi-Fi 7 card rounds things off nicely.

Do you sense a "but" coming? Well, I have a few. First, the speakers are loud and detailed, but their harshness made me reach for my headphones. Second, the 1080p webcam is okay for video calls but lacks the clarity of the best. If you've used the advanced AI tools built into recent HP and Lenovo laptops then you won't be wowed by the AI skills here, either, which are limited to basics such as Smart Guard (which turns off the screen if it spots you leave) and mic noise cancellation.

But the one area where MSI really falls behind its rivals is the keyboard. I found myself mis-hitting keys due to their shortness, and there's very little dampening. And the half-height cursor keys are almost perversely difficult to use. The two plus points are the punchy backlighting (which automatically appears as your fingers come close) and the keys' quietness.

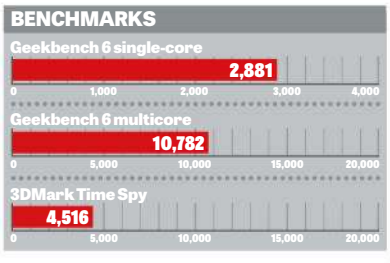
However, these gripes are ameliorated by the price. As we go to press, you can buy this incredibly light system – which includes that top-notch processor, 32GB of RAM and a 1TB SSD – from Currys for £999, and its Core Ultra 7 sibling for £899. That's astonishingly good value for money, so if you can live with the keyboard it's a bargain hunter's dream. **TIM DANTON**

ABOVE The lightweight Prestige 13 is a bargain, with the Core 7 Ultra version costing £899

ABOVE The keyboard shines brightly but is not the best for typing

"The OLED screen looks fantastic in games and films. It covers the whole of the DCI-P3 space, and beyond"

LEFT There are plenty of useful ports, including two USB-C connectors



SPECIFICATIONS

8-core (4 P-cores, 4 E-cores) Intel Core Ultra 9 288V processor • Intel Arc 140V graphics • 32GB LPDDR5X-8533 RAM • 13.3in 60Hz non-touch OLED panel, 2,880 x 1,800 resolution • 1TB M.2 PCIe Gen 4 SSD • Wi-Fi 7 • Bluetooth 5.4 • 5MP IR webcam • HDMI 2.1 • 2 x Thunderbolt 4/USB-C 4 • USB-A 3.2 Gen 1 • 75Wh battery • Windows 11 Home • 299 x 210 x 16.9mm (WDH) • 967g • 1yr RTB warranty • part code 9S7-13Q322-012

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pro-series

mid [PRO1]

£449.99

CPU	AMD RYZEN 5 8500G
Core	6 Cores - 12 Threads
Clock	(3.5/5Ghz Turbo)
Mob	ASUS TUF A620M-PLUS WIFI
RAM	ADATA 16GB DDR5 5600Mhz
M.2	TRANSCEND 1TB M.2 nVME
GPU	AMD RADEON Graphics
Case	KOLINK Observatory HF MESH
O/S	*NO OPERATING SYSTEM*
PSU	BUILDER 500W PSU

Max [PRO2]

£979.99

CPU	AMD RYZEN 5 7600X
Core	6 Cores - 12 Threads
Clock	(4.7/5.3Ghz Turbo)
Mob	ASUS PRIME B650M-A WIFI II
RAM	ADATA 32GB DDR5 5600Mhz
M.2	TRANSCEND 1TB M.2 nVME
GPU	NVIDIA RTX4060 TI 16GB
Case	1stPlayer D3-A aRGB - Black
O/S	*NO OPERATING SYSTEM*
PSU	CIT 700W PSU

UBER [PRO3]

£1159.99

CPU	INTEL Core i5 14600K
Core	14 Cores - 20 Threads
Clock	(2.6/5.3Ghz Turbo)
Mob	ASUS B760M-K
RAM	ADATA 32GB DDR5 5600Mhz
M.2	ADATA 2TB S70 Blade M.2 nVME
GPU	NVIDIA RTX4060 TI 16GB
Case	GAMEMAX F15M MESH
O/S	*NO OPERATING SYSTEM*
PSU	BEQUIET 850W Gold PSU

Aurora RANGE

i3 Aurora [AUR1]

£629.99

CPU	INTEL Core i3 14100F
Core	4 Cores - 8 Threads
Clock	(3.5/4.7GHz)
Mob	ASUS B760M-K
RAM	ADATA 16GB DDR5 5600Mhz
M.2	TRANSCEND 1TB M.2 nVME
GPU	NVIDIA RTX3050 8GB
Case	GAMEMAX Abyss Mini RGB
O/S	MICROSOFT Windows 10/11
PSU	CIT 600W Bronze PSU

i5 Aurora [AUR2]

£999.99

CPU	INTEL i5 14400F
Core	10 Cores - 16 Threads
Clock	(Turbo 4.7Ghz)
Mob	ASUS B760M-K
RAM	CORSAIR 32GB DDR5 6000Mhz
M.2	ADATA 2TB M.2 NVMe
GPU	NVIDIA RTX4060 8GB
Case	CORSAIR iCUE 4000X
O/S	MICROSOFT Windows 10/11
PSU	CORSAIR 650W PSU

i7 Aurora [AUR3]

£1599.99

CPU	INTEL Core i7 14700KF
Core	20 Cores - 28 Threads
Clock	(3.4/5.6Ghz Turbo)
Mob	ASUS PRIME Z790-P WIFI - DDR5
RAM	CORSAIR 32GB DDR5 6000Mhz
M.2	ADATA 1TB S70 Blade M.2 nVME
GPU	NVIDIA RTX4070 12GB
Case	CORSAIR iCUE 4000X RGB
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Lenovo Idea Tab Pro

A great-value rival to the iPad due to its 12.7in screen and bundled stylus, even if the OS can't match Apple's

PC PRO RECOMMENDED

SCORE ★★★★☆

PRICE 128GB with stylus, £317 (£380 inc VAT) **from** lenovo.com

Lenovo's latest tablet costs roughly as much as a basic iPad (*see issue 364, p91*), but it offers a bigger screen and stylus at no extra cost. Expansion is cheaper, too: while the 128GB model costs £380 inc VAT, you can find the 256GB variant on the high street for only £20 more.

The design isn't the most thrilling, but the smooth metal casing is pleasant to the touch and gives an impression of durability. At 620g it's on the weighty side, but that's down to the large 12.7in display. While the 8mm bezels are chunky, they help you easily hold the tablet by its edges without accidentally triggering the touchscreen.

Another nice design touch is the strong magnetic patch at the back of the Idea Tab Pro, to which the stylus attaches with a secure snap. The stylus doesn't charge when it's attached in this way – it tops up via a standard USB cable – but it has great battery life with more than 150 hours of standby time, so recharging isn't tedious. Although the stylus isn't quite as accurate as the latest Apple Pencil, I found it worked brilliantly, with impressive precision and pressure sensitivity.

Most unusually, the Idea Tab Pro also has a microSD card slot – ideal for expanding your storage or transferring files from a laptop – along with three accessory connector pins at the bottom, for connecting the optional Lenovo keyboard. Buy direct from Lenovo and you'll find various bundles that include this.

The big screen uses IPS technology so isn't as vibrant as OLED rivals, but colours still look punchy: it covers 76% of the DCI-P3 colour space to 71% for the iPad. I loved its smooth 144Hz refresh rate, too. This is a big win over the 60Hz screens found on other tablets, including even the iPad Air (*see issue 368, p56*), with the extra smoothness instantly noticeable when scrolling websites. Viewing angles are also strong, making it easy to use the tablet either propped up on a stand or flat on a table.

Audio is yet another strength. The four JBL-tuned speakers go loud without losing detail and offer a punchy sound profile without being too heavy on the bass. Throw in Dolby Atmos support and you have a sound system that can do justice to intense action movie moments. And what a pleasure to enjoy music videos without having to bother with headphones.

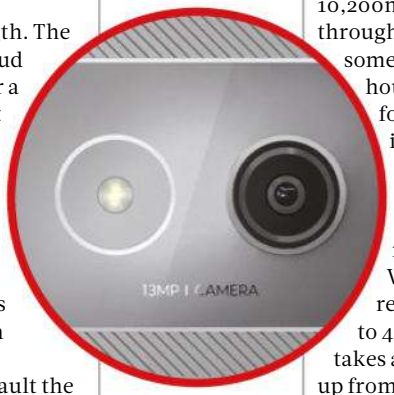
The only area where I can fault the media experience of the Idea Tab Pro is brightness. Its 400cd/m² peak is fine indoors, but it's overwhelmed by bright sunlight; if your summer plans include reclining on a deckchair and using your tablet as an outdoor e-reader, the OnePlus Pad 2 (*see issue 364, p86*) is a better bet, peaking closer to 600cd/m².

Lenovo's spin on the Android OS includes several features I rather like. For example, the Entertainment Space on the home screen combines all your streaming services to present a single page of recommendations and an integrated search.

The 12.7in format also lends itself to multitasking, and Lenovo's OS adds controls for displaying two apps side by side, or viewing them in floating windows. The USB-C port supports DisplayPort as well, so you could hook it up to a monitor to turn it into a desktop workstation. Alternatively, the Smart Connect app lets you wirelessly connect the tablet to your PC to share files and even directly control it from your computer.

Expect solid speeds. The MediaTek Dimensity 8300 processor and 8GB of RAM are both mid-range specifications, but I tried multitasking with a range of apps and saw no obvious slowdown. *Call of Duty: Mobile* ran perfectly too, never dipping below 60fps after I cranked the settings up to Very High. Even the more demanding *Zenless Zone Zero* ran smoothly at 30fps, albeit on Low graphical settings.

ABOVE The Idea Tab Pro's 12.7in display provides a smooth 144Hz refresh rate



ABOVE A rear 13MP camera accompanies the 8MP front lens

The Idea Tab Pro's enormous 10,200mAh battery easily gets you through an entire day of use and then some. I used the tablet to watch an hour of TV every evening and found I didn't need to recharge in a week. It also holds its charge well when idle; I left it in my bag for a few days, then picked it back up without needing to run for a charger. When the time does come to recharge, the tablet supports up to 45W power delivery, which takes about two hours to fully juice up from zero. That's nothing exceptional, but fine for the price.

While it doesn't match up to Apple's silicon for sheer performance, the Idea Tab Pro is a strong rival for general productivity or gaming, offering a bigger screen, a smoother refresh rate and awesome speakers. Let's not forget Lenovo's custom OS features either, which aren't matched by the iPad – or other Android tablets.

"The Idea Tab Pro is a strong rival for general productivity or gaming, offering a bigger screen, a smoother refresh rate and awesome speakers"

Before buying it's worth remembering that many leading tablet apps are still exclusive to Apple's ecosystem, including stylus-driven art tools such as Procreate. The Lenovo's extra weight and girth also make it less convenient than a standard iPad as a take-anywhere sketch pad. In all, though, it's a great all-round tablet at an excellent price. **DASHIELL WOOD**

BELOW The bundled stylus and optional keyboard add plenty of extra functionality

SPECIFICATIONS

8-core 3.35GHz/3.2GHz/2.2GHz MediaTek Dimensity 8300 SoC • Mali G615-MC6 graphics • 8GB RAM • 12.7in 144Hz IPS touchscreen, 2,944 x 1,840 resolution • 128GB/256GB storage • 13MP rear camera • 8MP front camera • Wi-Fi 6E • Bluetooth 5.3 • USB-C 3.2 Gen 1 • 10,200mAh battery • Android 14 (two OS updates) • Lenovo Tab Pen Plus • folio keyboard • 292 x 6.9 x 189mm (WDH) • 620g • 1yr C&R warranty

Xiaomi Pad 7 Pro

Pluses include a high-res screen, powerful processor and fast charging, but AI features remain iffy

SCORE ★★★★☆

PRICE 256GB, £416 (£449 inc VAT)
from mi.com

Chinese brand Xiaomi has a knack for offering top-end specs at competitive prices, and that's exactly what you get with the Pad 7 Pro. For two-thirds of the price of an iPad Air (*see issue 368, p56*), it combines one of the most powerful Android chipsets with a bright, sharp screen and ultra-fast charging.

The £449 model comes with 8GB of RAM and 256GB of storage, but moving up to 12GB RAM and 512GB of storage only costs an extra £50 – a great-value upgrade. A further £50 buys a version with matte glass, for a tasteful, professional look with minimal reflections. The standard models come in blue, green and grey, while the matte version is only available in grey.

The design isn't exactly distinctive, with the same flat-edge unibody chassis that most tablets have followed since the iPad Pro introduced it seven years ago. It's popular for a reason, though: the design looks svelte (6.2mm) and feels solid. My only gripe about the construction is that Xiaomi doesn't cite an IP rating for the Pad 7 Pro, which implies it lacks significant protection against dust or water.

The tablet's 11.2in screen has a comfortable 3:2 aspect ratio and an unusually high resolution of 3,200 x 2,136, translating to a pixel density of 345dpi. That's higher than any iPad, and more than sharp enough to enjoy films, TV shows and games. The maximum brightness of 800cd/m² pops nicely too, while the 144Hz adaptive refresh rate ensures everything is beautifully smooth. There's even support for Dolby Vision HDR when streaming from supported sources such as Netflix.

Dolby Atmos audio isn't such a hit. The four speakers around the tablet go loud but don't sound much better than a smartphone, and I found myself using headphones when streaming films.

The system software is Xiaomi's HyperOS 2, based on Android 15. This doesn't change many layout or design features of Android, but it adds useful capabilities such as wirelessly connecting the tablet to a Windows PC or Mac as a screen extension and syncing with other Xiaomi gadgets.

A few AI features are on offer, too, but I have mixed feelings about these. To use them you have to create a Xiaomi account, sign in and install the desired features. Quite a pain. Even more so when I found they worked inconsistently; for example, the speech-to-text transcription tool is excellent, but the object removal tool struggled to identify the items I wanted to erase from photos. Xiaomi's AI tools are also limited to the Pad 7 Pro's pre-installed software suite, so you can't use the AI writing tool in other apps such as Google Docs.

A Qualcomm Snapdragon 8s Gen 3 chip runs the show. This doesn't match the raw performance of the iPad Air – it scored around 2,000 in Geekbench's single-core test and 6,000 in multicore, compared to 3,000 and almost 12,000 for the Air – but it's still a strong performer in regular apps. I never saw any serious stuttering, even at games' highest settings, with my only notable criticism being that the chassis became hot if I gamed for too long in one session.

ABOVE The Pad 7 Pro is a big step up from budget Android tablets

The twin cameras on the Pad 7 Pro are a welcome surprise. The rear camera module sticks out in a way that makes the tablet wobble when laid flat on a desk (unless you add a case), but it houses a high-res 50MP sensor with optional Portrait and Night shooting modes, meaning you can take fine shots with this tablet. The 32MP front camera is a cut above average too, while privacy-conscious users will appreciate the small green LED on the top bezel that lights up when either camera is on.

It's all powered by an 8,850mAh battery, and Xiaomi estimates that this can keep the tablet running for 19 hours of video playback. It will definitely get you through a full day with bags to spare. And it recharges faster than almost any other tablet, thanks to a 67W charging option that takes only 80 minutes to power up from empty to full.

"The 11.2in screen has an unusually high resolution of 3,200 x 2,136, translating to a pixel density of 345dpi. That's higher than any iPad"

To further extend the Pad 7 Pro's usefulness, Xiaomi offers a few practical accessories, although these are pricey. The basic keyboard stand is £119, while the Focus Keyboard – which includes a trackpad and an adjustable viewing angle, reminiscent of Apple's Magic Keyboard – costs £179. The stylus is an extra £89 on top.

Still, if you're looking for an Android tablet that's a step up from the plentiful budget options, the Pad 7 Pro is a solid option. It's well built and snappy in use, the screen is excellent, and even with the pricey accessories it works out far cheaper than an equivalent iPad Air. **TOM BEDFORD**

LEFT The keyboard and stylus are pricey optional extras

SPECIFICATIONS

8-core 3GHz/2.8GHz/2GHz Qualcomm Snapdragon 8s Gen 3 SoC • Adreno 735 graphics • 8GB/12GB RAM • 11.2in 144Hz IPS touchscreen, 3,200 x 2,136 resolution • 256GB/512GB storage • dual 50MP/2MP rear cameras • 32MP front camera • Wi-Fi 7 • Bluetooth 5.5 • USB-C 3.2 Gen 1 • 8,850mAh battery • Android 15 with Hyper OS 2 • 251 x 6.2 x 173mm (WDH) • 500g • 1yr warranty

Huawei MatePad Pro 13.2 (2025)

Yet another brilliant piece of hardware design from Huawei, but the lack of apps is too big a drawback

SCORE ★★★☆☆

PRICE £833 (£1,000 inc VAT)
from consumer.huawei.com

It's the economy, stupid. So said James Carville during Bill Clinton's 1992 presidential campaign, and it didn't take long for "it's the software, stupid" to enter the vernacular. And that truth remains: you can build the best hardware in the world, but if it doesn't run software you want to use then it's nothing more than a fancy web-surfing machine.

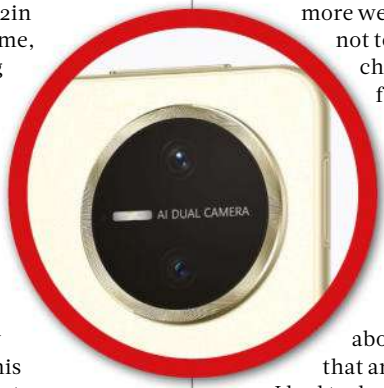
At a grand, the Huawei MatePad Pro 13.2 is far too expensive to be a mere web-surfing machine. But it's definitely fancy. The first sign of this is its slim, stylish frame, which feels as well made as any iPad. That's despite packing a 13.2in panel into a 580g frame, which means it's 35g lighter than the 13in iPad Air (*see issue 368, p56*).

The screen is another highlight. I would go so far as to say it's the best I've seen on a tablet. Most OLED panels are covered in glossy glass to emphasise this technology's excellent reproduction of colours, but Huawei takes a different approach and applies a matte finish. And it's glorious. Whether inside or out, in dim or bright conditions, you'll love both its colours and its sheer smoothness: once you've experienced 144Hz refresh rates, it's hard to go back.

To back up that subjective feeling with cold, hard figures, the panel covers 99% of the DCI-P3 gamut (that compares to 83% for the iPad Air) in its Vivid mode with an average Delta E of 0.5. So, excellent reproduction all round. Switch to Normal mode and it matches almost perfectly to the sRGB gamut, covering 99% and with an even better average Delta E of 0.34. Whites also look stunning, as reflected by its 6591K colour temperature (very close to the target 6500K).

You also benefit from Huawei's third-generation M-Pencil as a "free gift". You need to pair this by placing it at the top right of the screen, and this is also how to charge the stylus. Huawei has worked hard to make using it a pleasant experience, with neat software tie-ins such as a quick access annotate option and writing notes on the screen when the tablet isn't active, but I'm still waiting for a paper-like feel of stylus against panel.

Then there's the excellent keyboard. This comes in the box, but unlike most "freebies" it's a genuine pleasure to type on, with a deep feel to the keys. Apple's Magic Keyboard is better still, but that adds much more weight and thickness, not to mention a hefty chunk of cash. The fact you get 512GB of storage (the equivalent iPad Air costs £1,099 without the Pencil or the keyboard) only adds to its attractions.



LEFT Photos from the twin rear cameras are as good as any tablet's

Want more? How about a set of speakers that are so good, so bassy, I had to double-check I wasn't listening to my Echo? Or the fact that the rear 50MP/8MP cameras actually take pictures you'll want to keep? They're also good for video, shooting 4K at 30fps or 1080p at 60fps. I wasn't so taken by the harsh front-facing camera, as used for video calls (1080p/30fps), but it's good enough for the daily grind of meetings.

BELOW With a stylus and keyboard thrown in, the MatePad Pro is great value

ABOVE The MatePad Pro 13.2 is hampered by the simple fact it doesn't use Android

"The screen is a highlight. Whether inside or out, in dim or bright conditions, you'll love the colours but also its sheer smoothness"

Bearing in mind this tablet's price, I hoped its performance would be closer to the iPad Air. A score of 111 in WebXPRT4 is better than the 90 of the £499 Lenovo Idea Tab Pro (*see p62*), but the Air scored 311. Likewise a 128 return in JetStream 2 is strong for an Android tablet (the Tab scored 83), but the iPad Air kicks sand in its face with 342. And that's it for comparable benchmarks: as the MatePad Pro runs HarmonyOS, none of our regular tests, such as Geekbench, runs on this tablet.

And therein lies the rub. While you will be able to perform many tasks via the web browser, there are some jobs that need an app. Which is a game of chance: OneDrive works, so you can edit Word and Excel docs, but while I could view Google Drive files there was no way to edit them. The page kept pushing me to an app that didn't exist for HarmonyOS. Patient people might find a way to sideload it, as Huawei's OS has much in common with Android, but I'm not one of those people.

There are also signs that Huawei's quality testing isn't what it used to be when it comes to English language users. I had to give up writing this review on the tablet as the keyboard slipped into Chinese Mandarin mode – I must have pressed something in error – and I couldn't find a way to switch it back. Some of the setup instructions were also in Chinese, requiring guesswork to finish setup and switch to English in the language settings. I hit a similar problem in AppGallery, Huawei's equivalent to the Play Store.

Previously, I've said that Huawei tablets remain strong choices due to the quality of the hardware and their value for money; it's not like buying a phone where Android or iOS are almost impossible to do without. This time, however, I'd warn 99% of people away and towards safer options such as the Lenovo Idea Tab Pro. It's slower, and the hardware isn't as good, but at least you know everything will work. **TIM DANTON**

SPECIFICATIONS

8-core 2.5GHz/2.15GHz/1.6GHz Huawei Kirin T92 SoC • Maleoon 920 graphics • 12GB RAM • 13.2in 144Hz OLED touchscreen, 2,880 x 1,920 resolution • 512GB storage • dual 50MP/8MP rear cameras • 16MP front camera • Wi-Fi 6 • Bluetooth 5.2 • USB-C 3.2 Gen 1 • 10,100mAh battery • Harmony OS 4.3 • magnetic keyboard • 289 x 5.5 x 196mm (WDH) • 580g • 2yr RTB warranty

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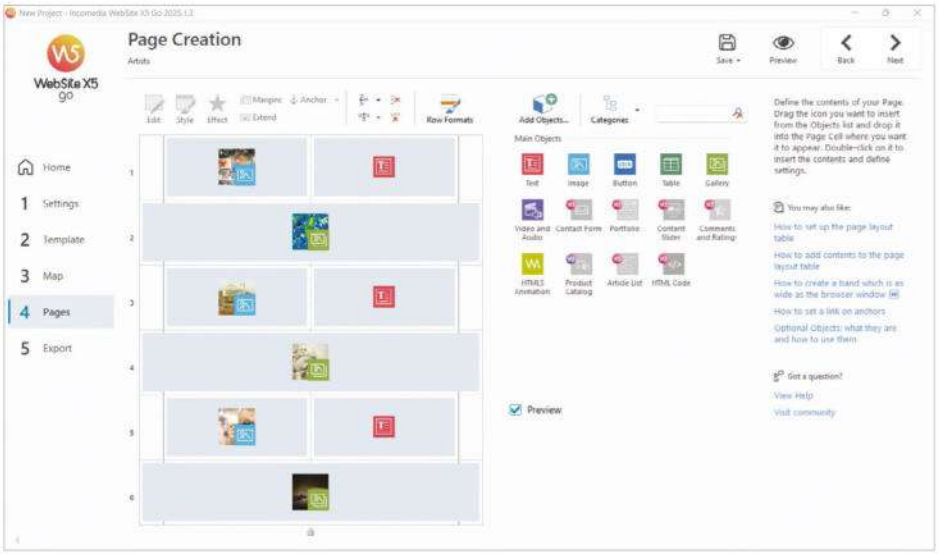

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REQUIRES Windows 10 or later; 300MB drive space; online registration

WebSite X5 Go 2025 is a powerful web-design tool that makes it easy to create top-quality, responsive websites – even if you have no design or coding experience. That's because it includes more than 25 eye-catching, professional templates covering just about every site type and topic area, from e-commerce to blogs, sports sites, animals, food, movies, web portals and more. The results don't only work well in a regular browser, either: they've been carefully coded to look great on any device, from a desktop PC right down to a smartphone.

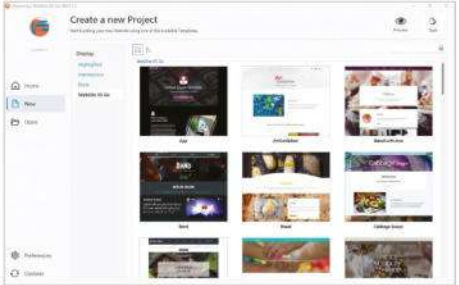
Your first job is to choose a design that appeals to you, after which you can start to plan out your site's structure using a map. This is a great way to get your site's flow and content clear in your mind.

From here, it's a simple case of populating each page in turn by dragging, dropping and cropping various elements on your page. There are text blocks, images, galleries, tables, video and audio widgets, maps, Flash animations, product catalogues, email forms and more to choose from.

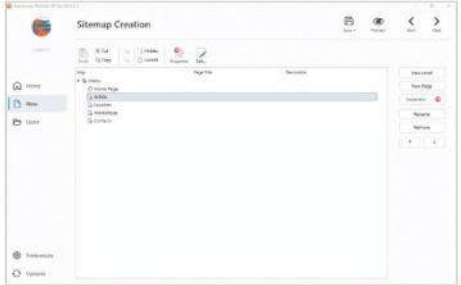
Each element can be styled in several different ways, so you can really make the site your own. For instance, the program doesn't just embed an image when you drop it onto the page; rather, you can define a quality setting and resize method as part of the operation. You can then apply a host of smart mouseover effects, such as zooming in and displaying custom text, and even set up some basic protection to make it more difficult for your site visitors to copy the image.

As you'll see when you first start working with the program, many of the supplied templates include some great-looking pages already. However, you don't need to stick with them in their default state – you can customise and tailor them to suit your preferences and requirements. Where a template includes a text box, for example, you could swap it for an image, and vice versa. You can also change the default page names and placeholder copy to ones that work better for you.

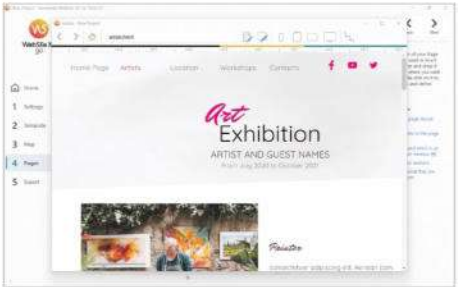
Since it's unlikely you'll manage to put together an entire site in one sitting, you can naturally save your progress as you go, as well as preview what you've achieved so far in a real browser. Alternatively, you can upload it to a server via Website X5 Go's built-in FTP engine for more rigorous testing – for example, to invite collaborators to log on and give you feedback.



ABOVE Start by choosing a template and you won't need to worry about wrangling the underlying code by hand



ABOVE Mapping out your site before you begin will help you to define a logical structure that you can follow while you add content



ABOVE You can explore your work in the application, preview it in a browser or upload it to a server for public testing

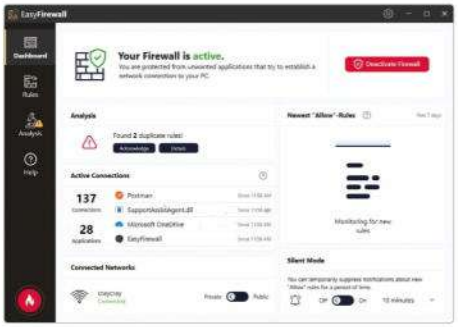
Backup Pro 25

- Back up and protect any amount of data, from a single file to a full partition, and save your data wherever you like
- Archives require 50% less storage space than those created by other backup solutions
- Backup tasks are performed automatically in the background, but can be paused at any time

Full product worth £50 ashampoo.com
REQUIRES Windows 10 or later; 200MB drive space; in-application registration

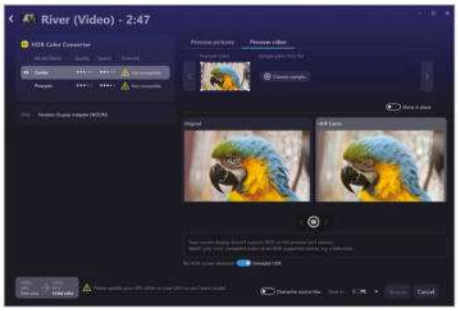
EasyFirewall 2025

- A user-friendly tool for monitoring and managing the integrated Windows firewall
- Check which applications are talking to external servers, audit their traffic and quickly create new rules to control their access
- Safely open up additional ports, which may be required by some games and services



Full product worth £30 abelssoft.de
REQUIRES Windows 10 or later; 10MB drive space; in-application registration

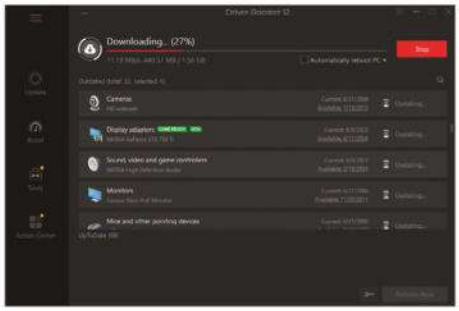
Audials Vision 2025.1 SE



SE product worth £15 audials.com
REQUIRES Windows 10 or later; 500MB drive space; online registration

- This brand new tool uses AI to enhance your videos automatically
- Upscale low-quality videos to 4K, convert to HDR and improve colour vibrancy
- Smooth out jerky video and enhance the sound

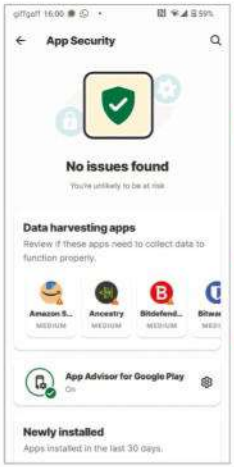
Iobit Driver Booster 12 Pro Uninstaller 14



Six months of updates worth £10 iobit.com
REQUIRES Windows 7 or later; 50MB drive space; online registration

- Scans your system for outdated drivers and automatically downloads the latest versions
- No complex interface, no searching: just launch, scan and check the detailed report
- Optional Express mode for one-click updates

Norton Mobile Security 2025



- Essential protection against threats to Android and iOS-powered phones and tablets
- Real-time protection and smart update scanner
- Includes Norton Safe Web protection to scan websites, search results, SMS messages and apps

One-device, one-year licence worth £30
uk.norton.com REQUIRES Android, iPhone or iPad device with recent OS release

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Eizo FlexScan FLT

A great choice for rollouts where power consumption is a priority – and the arm is an absolute triumph

SCORE ★★★★½

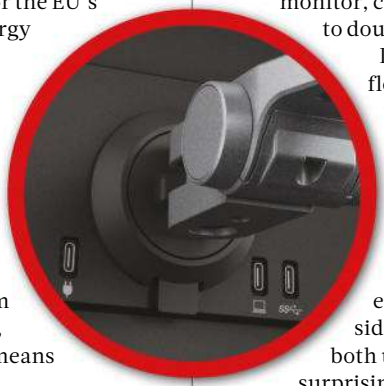
PRICE £396 (£475 inc VAT) **from** eizo.com

PC PRO RECOMMENDED

Do you know how much power your monitor consumes? A safe bet is 20W to 30W at a comfortable brightness – around 200cd/m² in an office – yet the 24in Full HD Eizo FlexScan FLT can work happily on 6W. Switch to Eco mode and that cuts in half to 3W, but the screen brightness also drops to a dim 99cd/m² so I wouldn't recommend it.

So watt, you ask? The answer is that when rolled out across an office, where you're replacing hundreds of monitors, there will be a measurable drop in power consumption without any loss of functionality. Almost as important, it plummets to 0.27W in power save mode.

All this means the FLT is the first monitor to qualify for the EU's "A" standard for energy consumption. It also meets TCO Certified Generation 10 and EPEAT Climate + standards. There's plenty more here for companies concerned about their ESG policy: the housing is made from 95% recycled plastic, reduced packaging means it consumes 42% less greenhouse gases during transit, and Eizo guarantees no conflict minerals in its supply chain.



On a more basic level, all FlexScan monitors include an excellent five years of "hassle-free" warranty as standard, including a six-month guarantee of zero bright sub-pixels. Eizo claims it has a less than 1% failure rate across that five-year period, too.

Aside from its eco credentials, there's one more thing that makes the FLT special, and that's its stand. More accurately, its arm. While monitor arms are nothing new, this is the best implementation I've seen: so long as your desk is between 10mm and 40mm thick, you simply slide the base into position and then tighten it using the built-in grip. No tools, no hassle. You then attach the monitor to the arm. My only comment is that it's far easier to perform this manoeuvre from the side or the rear; trying to slot it in from the front, peering over the top of the monitor, caused my swear jar to double in value.

It's a well-built and flexible arm, too. A telescopic extender means you can pull it 80mm closer when wanted and push it out of the way when you don't. It also twists easily from side to side, while a 40° tilt, both up and down, is surprisingly useful. You can push it right down to almost touch the desk, or lift it up to a peak of 225mm above your desk (when I measured). The only thing it can't do is pivot.

Eizo has also committed to USB-C with the FLT. There's no HDMI, no DisplayPort, only a USB-C upstream port, a USB-C downstream port and a USB-C power input. While it comes with a (chunky) 90W power supply, it can happily survive on the power provided over the USB-C cable that attaches it to your laptop (you can also daisy-chain it to a monitor, if that monitor has a USB-C output). Attach the supplied power brick and it can feed up to 15W to the downstream USB-C port and up to 60W to your laptop. That's enough for most models, but power-hungry systems such as a MacBook Pro will grumble that it's insufficient.

As the graphs below indicate, this is a top-quality panel. Switch to the sRGB preset and it locks almost perfectly to that space, meaning you can trust the colours thanks to this panel's excellent colour accuracy. The average Delta E is great, while its worst result of 0.96 reveals that colours will look perfect. Whites look superb in sRGB mode, too.

Eizo's OSD makes it easy to switch between presets. There's DICOM for medical locations, plus two user settings, Eco, sRGB, Paper (sepia) and Movie. You don't get much in the way of controls – hue, saturation, gain, colour temperature – but this screen isn't aimed at photographers, designers or video editors. It's a business workhorse. There's even a touch of style, with what Eizo calls a "floating edge frame" around the 24in panel.

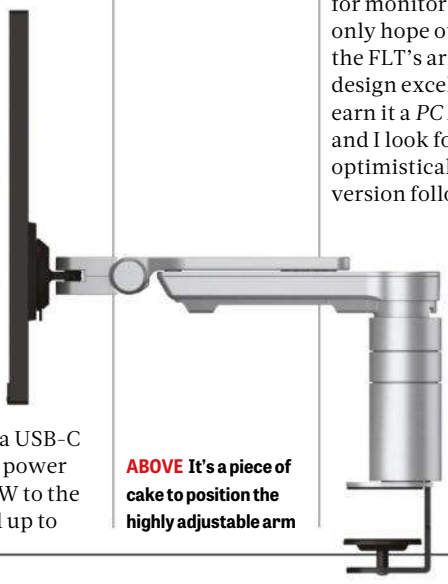
ABOVE Eco-conscious and well designed, the FLT provides superb image quality, too

"It sets a new standard for monitor efficiency we can only hope others will aim for, while the arm is quite simply a piece of design excellence"

Which brings us finally to price. Eizo told me that stock is limited for the FLT, and that means it's likely to stick at its list price of £396 exc VAT. That's almost six times the price of the perfectly respectable 24in Full HD monitors you can buy at online retailers, while Dell's most basic "Pro" monitor costs £80 exc VAT. Even if you assume much lower failure rates by buying Eizo, that's a tough sell to get by your CFO.

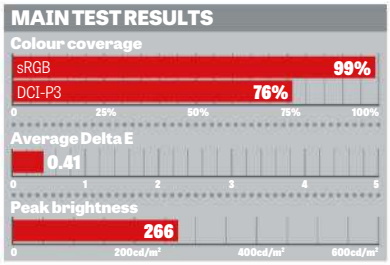
So I don't expect this monitor to top the list for volume sales any time soon. However, it sets a new standard for monitor efficiency that we can only hope others will aim for, while the FLT's arm is quite simply a piece of design excellence. Those two factors earn it a *PC Pro* Recommended award, and I look forward – perhaps optimistically – to a 27in 1440p version following soon. **TIM DANTON**

LEFT All the inputs and outputs are of the USB-C variety



ABOVE It's a piece of cake to position the highly adjustable arm

MAIN TEST RESULTS



All measurements in default profile

SPECIFICATIONS

23.8in 1,920 x 1,080 IPS panel • 60Hz refresh rate • 8-bit panel (16.7 million colours) • 5ms response time • USB-C 3.2 Gen 1 (60W power delivery) • USB-C downstream (15W) • 180° swivel • -40° to 40° tilt • 550 x 230mm (W x H, no stand) • 2.5kg (no stand) • 5yr warranty

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Dell Pro 14 Plus (P1425)

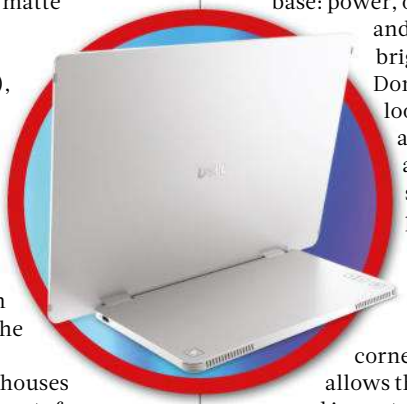
A great-looking mobile monitor, but it's about £100 too expensive given its resolution and features

SCORE ★★★☆☆

PRICE £219 (£263 inc VAT) **from** dell.com

This is the second product we've seen after Dell's big rebrand, announced at CES. From now on, all its new professional products will include the name "Pro", whether it's a monitor, a desktop PC or a laptop. We saw a top-of-the-range Premium model last month in the Dell Pro Premium 13 laptop (*see issue 368, p46*), and this month is the debut of a Plus product. That is, one that sits in the middle of the range in terms of quality.

If the Dell Pro 14 Plus is anything to go by, they're all going to be good-looking devices. This is a sleek device with a thin, lightweight aluminium chassis that weighs only 570g. Close examination reveals the plastic framing around the matte display (maybe the Premium version would be all metal?), with thick bezels along the top and bottom. And there's no doubt who made it: the Dell logo is featured in the centre of the bottom bezel and again on the back of the display.



A weighted base houses all the controls and ports for the monitor. You'll find a USB-C port on either side, both of which can be connected to a host laptop or smartphone. You may find that your phone doesn't provide enough power (it needs 7W), but there isn't a power brick in the box so you'll need to provide your own.

Dell does include a one-metre USB-C to USB-C cable in the box, which wouldn't normally be worth mentioning except that one end features a connector twisted through 90°. This allows the USB-C cable to tuck neatly behind the display panel, out of sight. I also applaud the inclusion of a fabric-covered pouch for transporting the Pro 14 Plus.

Four buttons line up on top of the base: power, orientation lock and up/down brightness control. Don't waste your time looking for speakers as they're aren't any, which is surprising at a price this high.

Rubber feet sit on the corners of the display and along the rear corners of the base. This allows the Pro 14 Plus to be used in portrait orientation on either side of your laptop without sliding around on your desk. Meanwhile, a built-in gyroscope will automatically adjust the picture's orientation when you switch from landscape or portrait mode (unless you activate the lock mentioned above). And the OSD... well, there isn't one. Again, surprising in a monitor at this price.

You might also expect a higher resolution than 1,920 x 1,200 – portable monitors such as the similarly priced 16in ViewSonic TD1656-2K offer 2,560 x 1,600 for a sharper image – but again you're out of luck. The good news is that the panel is covered with a matte finish to lessen reflections. And its colour coverage isn't bad either, with all of the sRGB gamut covered along with 71% of the DCI-P3 range. Yet another plus point is its peak brightness of 439cd/m² (the ViewSonic TD1656-2K maxed out at 363cd/m²).

This monitor is built with productivity in mind, so that's how I used it for more subjective testing. Keeping Word on my main display, I used the Pro 14 Plus to swap between Excel, Microsoft Edge, Slack and Pixelmator Pro. This is where the lack of pixels became evident, as Edge and Pixelmator in particular were only happy if they could hog the whole display. Excel and Slack could begrudgingly share the pixels.

For work tasks, the matte display works well, particularly in environments such as hotel rooms where you might have awkwardly positioned lighting. Switching to films made me long for a glossy screen, but I still enjoyed the well-saturated colours in Disney's *Lightyear*. Until, that is, I placed the Pro 14 Plus next to the ViewSonic TD1656-2K, and suddenly its stronger colours, higher resolution and glossy finish made me gently disconnect the Dell and carry on with the film.

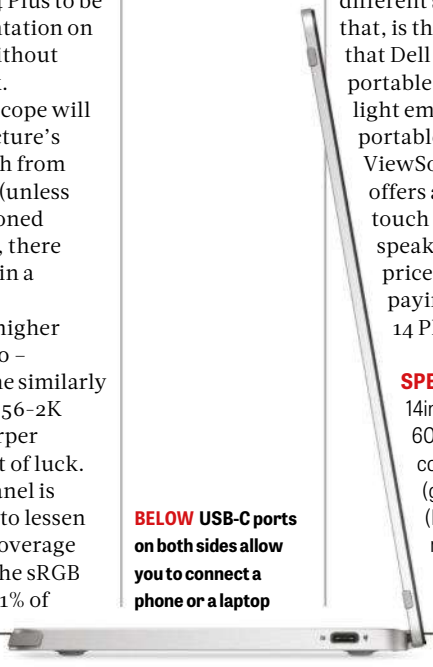
It's hard to argue with the Dell Pro 14 Plus's fundamentals. This 14in, 1200p display is bright and colourful, and the build quality is impeccable. It also includes a versatile stand that allows the monitor to be used in landscape or portrait mode, and let's not forget its biggest win: portability. It's thin and light enough to easily justify its place in a suitcase, especially as Dell includes a carry case in the box.

"Dell has made too many sacrifices. Where are the speakers? Where's the OSD to tune the panel for different scenarios?"

However, Dell has made too many sacrifices. Where are the speakers? Where's the OSD to tune the panel for different scenarios? Where, come to that, is the "ComfortView" button that Dell used to include in its portable monitors to reduce blue light emissions? When you can buy portable monitors such as the ViewSonic TD1656-2K – which offers a 16in, 2,560 x 1,600 display, touch support and built-in speakers – for a very similar price, there's no justification for paying Dell this much for the Pro 14 Plus. **BRANDON HILL**

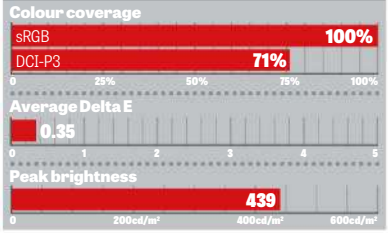
ABOVE **The Pro 14 Plus is bright and colourful, but its resolution could be higher at this price**

LEFT **The base houses all the controls and ports for the monitor**



BELOW **USB-C ports on both sides allow you to connect a phone or a laptop**

MAIN TEST RESULTS



All measurements in default profile

SPECIFICATIONS

14in 1,920 x 1,200 IPS panel up to 60Hz • 8-bit panel (16.7 million colours) • 7ms response time (grey to grey) • 2 x USB-C (DisplayPort 1.2 Alt mode) • portrait mode • 10° to 90° tilt • 315 x 224 x 14.7mm (WDH) • 570g • 3yr advanced exchange warranty

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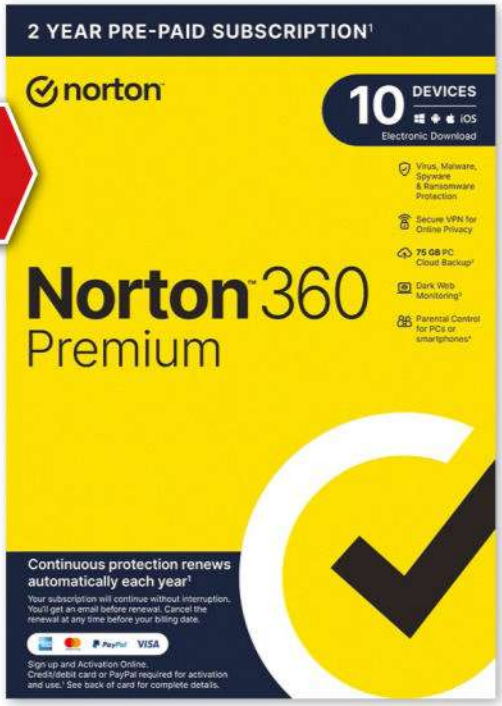
Norton Parental Control provides tools to see exactly what your kids are up to on their various devices, and you also get GPS location monitoring for Android and iOS.

To round things off, Norton Password Manager generates and stores passwords across all your devices, while SafeCam for PC stops cybercriminals attempting to take photos with your webcam without your knowledge.



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Want to upgrade from Windows 11 Home to Windows 11 Pro? Or perhaps you're looking to move up from Windows 10 Home?

Whatever your motives, a Windows 11 Pro upgrade licence is a great choice. The first reason is simple: price. Microsoft charges £119.99 for a retail licence of Windows 11 Home, a staggering £219.99 for Windows 11 Pro, and £119.99 for its own upgrade licence from 11 Home to Pro. By choosing this licence – and avoiding the many dubious sources of licences you may find online – you cut that price substantially.

Unlike Windows 11 Home, Windows 11 Pro enables you to connect to a business domain. It also provides BitLocker to encrypt whole drives. Best of all, you can create and host virtual machines using Hyper-V, which is ideal for testing new software or, if you're a developer, seeing how your software performs on a fresh OS.

Note that the upgrade only works from an activated copy of Windows 11 Home, so if you're currently using a Windows 10 Home system then you'll need to upgrade from that to Windows 11 Home before this upgrade can work.

Want to upgrade from Windows 7 or 8? Or building a PC from scratch? Then head to **tinyurl.com/windowspro11** and grab a full 1-PC licence for Windows 11 Pro for only £79.99.

NORTON UTILITIES ULTIMATE 2025 for £10

10 PCs | 1YR LICENCE

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tinyurl.com/nortonutils

Not only does Norton Utilities pack several components, it also offers more than one way to use them. For people who don't want to get too involved, there are one-click options for quick results. But you can also work through all of the recommendations the software offers after analysing your computer.

The Dashboard provides a handy overview of your system, complete with explanations for any detected issues. This can range from problems in the Registry and junk files wasting space to unnecessary startup programs increasing boot times and slowing down your computer. Click the "Repair All" button to apply all of the recommendations, or spend time checking which you would like to use.

Then there's the Norton Utilities Toolbox, which includes five individual cleanup tools: all-in-one cleanup, internet cleanup, Windows cleanup, Registry cleanup and an advanced uninstaller.

Norton provides yet more tools in the self-explanatory Speed Up section, including a memory optimiser, startup time reducer and defragmenter. The Protect section is home to privacy-related tools such as a secure file shredder, while the Recover section is there to help fix problems.

There's one final problem Norton can help you with: cost. Your one-year licence costs £10 – a £19.99 saving over the full price – and allows you to boost the performance of up to ten computers.

Potensic Atom 2

A fantastic drone for budget-conscious pilots, capturing smooth 4K/30fps video and detailed 48MP stills

SCORE ★★★★★

PRICE Standard kit, £250 (£300 inc VAT) from amazon.co.uk

Potensic made a splash in 2023 with its cheap yet capable Atom drone. The Atom 2 brings big improvements while keeping the same low price: £300 includes the battery and controller, while £400 for the "Fly More Combo" adds two spare batteries, a charging hub and a carrying bag.

The drone is as tiny as its name suggests, weighing just under 250g. This means you can legally fly it in residential, recreational and commercial areas that are usually out of bounds to heavier drones. There are still regulations you'll need to comply with, though, so do your research before you take to the skies.

Despite its low weight, the Atom 2 is solidly built; I accidentally crashed it twice into tree branches during testing, and it didn't sustain the slightest damage. For more serious mishaps, the Fly More kit also includes eight pairs of spare propellers, 16 screws and two smartphone connector cables for the all-new controller.

This is included with the standard and bundle variants, and feels far more premium than the previous model. It attaches neatly to almost any phone, even chunky ones – I used my Google Pixel 7 Pro without removing its case. When not in use, the two joysticks pull off and slot into the controller's underside for easy transport.

The new Eve app is clean and intuitive. This provides a live view from the drone's camera while you're flying, and when you're finished allows you to review your past videos and photos, along with flight logs and data. Its only notable omission is a map to help you easily see where it's safe to fly and where restrictions apply; head to **noflydrones.co.uk** to check up on this.

These aren't the only improvements over the first-generation Atom. The Atom 2's maximum flight distance is double the original's at six miles, similar to many DJI drones. The all-important camera has been upgraded, too, with a larger sensor that can capture brighter, better images at a 48MP resolution; the Atom 2's main competitor, the DJI Mini 4K, is limited to 12MP. The Atom 2 can also record video at up to 30fps in 4K or 60fps at 1080p.

As before, you get a selection of preset flight patterns that use AI to keep you in the frame as the drone zips about. These all work superbly for creating quick, social media-friendly content – but the Atom 2 brings an AI Track option, which literally follows you around as you walk. It works fantastically, and is joined by an AI Night shooting mode that enhances what lies hidden in the shadows in murky conditions. As well as helping to capture more detail in low light, this is helpful for flying safely in poor visibility.

The Atom 2 retains some of the limitations of the original Atom. Because it's so light, it's liable to be buffeted around in windy weather – which is particularly concerning as the Atom 2 doesn't have any collision-avoidance sensors. This means you must take great care when flying next to trees, under bridges and so forth (as is normal in this price range), but the app does warn you if the drone is in danger of being blown off course.

ABOVE Lightweight yet durable, the Atom 2 is a fantastic drone

PC PRO RECOMMENDED

LEFT The 4K, 30fps camera shoots stunning videos

Images from the Atom 2's camera are highly detailed. In automatic mode I found it captured excellent stills, but you can engage manual mode to take control of shutter speed, aperture, ISO and white balance. There's no raw mode and no optical zoom, although you can activate a 2x digital zoom if you're willing to sacrifice quality.

When it comes to video work, the Atom 2 simply kills. Every piece of footage I shot came out crystal clear; colours were stunning, while motion was smooth thanks to the three-axis mechanical gimbal.

The Atom 2's maximum flight time of 32 minutes is par for the course – officially it's one minute more than DJI's competing models, but it all depends on how you fly it. The battery recharges via USB, or if you opt for the Fly More package you can use the charging hub to charge all three batteries at once. This took just under two hours.

"When it comes to video work, the Potensic Atom 2 simply kills. Every piece of footage I shot came out crystal clear"

You can probably tell that I'm a massive fan of the Potensic Atom 2. The original Atom was a great debut, but the improved controller and user-friendly app make this drone an absolute joy to fly, while features such as automatic subject tracking and the Night Mode ensure it's easy to capture excellent video. The DJI Mini 4K is a worthy rival for a similar price, but it's hard not to love the lightweight, durable Atom 2. **NIKITA ACHANTA**

BELOW The standard package includes the controller, while the Fly More kit adds a host of useful extras

SPECIFICATIONS

48MP camera (79° FoV, 4K video at 30fps) • 2,230mAh battery • microSD card slot • Wi-Fi 5 • Bluetooth 4.2 • GPS, GLONASS, Galileo, BeiDou • remote controller • 143 x 58 x 88mm (WDH, folded without propellers) • 245g • 1yr warranty

RayNeo Air 3s

Well-priced AR glasses that are ideal for long journeys thanks to a gorgeous picture and clear audio

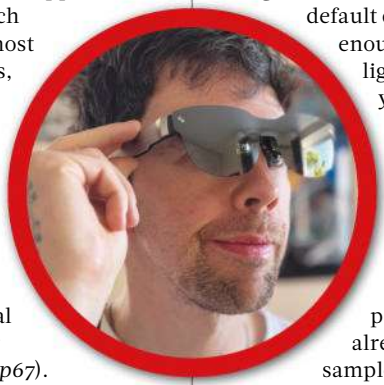
PC PRO RECOMMENDED

SCORE ★★★★☆

PRICE $269 plus import duty from rayneo.com

Established in 2021, RayNeo has made its mark producing simple, affordable smartglasses. It doesn't try to match the rich feature sets of competitor Xreal, instead focusing on price – something the Air 3s, its latest model, sticks to while offering improved performance and vastly superior audio over prior generations.

To be clear, this isn't a self-contained VR headset such as the Meta Quest 3. It's a virtual display that plugs into a host device and simulates a huge 201in screen, floating six metres in front of your face. It will work with almost any device that supports video over USB, which means you can use most smartphones, tablets, PCs and Macs.



When I opened up the RayNeo Air 3s glasses I initially thought there had been a mix-up in the shipment sent to me, because they look and feel identical to the older, cheaper Air 2s (*see issue 361, p67*). This is both good and bad – the design is stylish by AR glasses standards, but the cheap plastic build doesn't inspire confidence. Especially as I was far from impressed by the video and audio quality of the 2s.

Design-wise, the front of the Air 3s is a shaded, single-piece lens, with silver-coloured, three-position arms at the sides; the left one houses a volume rocker and a menu button, while the right arm has a brightness rocker and a USB-C port at the end for connecting to your host device. The supplied cable has a slight downward bend, which prevents it from sticking straight out behind you.

On the inside of the lens, the Air 3s use Sony micro-LED panels, as do most consumer AR glasses. These offer a crisp 1080p resolution with a smooth 120Hz refresh rate, and RayNeo's own HueView screen technology to deliver a rich palette of colours. As a result, the Air 3s comply with the IMAX Enhanced standard, covering 98% of the cinematic DCI-P3 space. They also boast a maximum brightness of 650cd/m² and a native contrast ratio of 200,000:1 – twice as bold as the Air 2s.

Since long-term wearing of AR glasses can cause serious eye fatigue, RayNeo has also implemented its 3,840Hz "OptiCare" dimming system, which regulates colour output and minimises flickering. However, unlike the Xreal One (*see issue 366, p70*), the lens doesn't feature electrochromic dimming, nor do you get a physical light blocker in the box. So if the default dimming isn't enough to block ambient light from ruining your viewing experience, you'll need to find a home-made (or third-party) fix.

Alongside the glasses, RayNeo supplies two nose pads (one of which is already installed), a sample frame for prescription lenses, a cleaning cloth and a hard carrying case. This is thoughtfully designed, with enough room for the glasses, the USB cable and the cleaning cloth.

While the Air 3s have the same resolution and refresh rate as the Air 2s, image quality is markedly better. With the older model, details became blurry towards the periphery of my field of vision, but I had no such issues here, even when spending many hours using the glasses to write and edit articles. And I'm delighted to report that RayNeo has also upgraded the audio system, which was a weakness of the Air 2s. A new four-speaker setup offers a claimed 200% boost in acoustic performance, and the distortion I noticed with the previous glasses is gone.

ABOVE The Air 3s offer crisp images and distortion-free audio

"The RayNeo Air 3s are a big step up from their predecessors. The audio upgrade is particularly significant"

This creates an experience that's ideal for entertainment, and I thoroughly enjoyed gaming on the Air 3s. *Microsoft Flight Simulator 2024* and *Forza Horizon 5*, running off a Lenovo Legion Go S handheld PC, were incredibly immersive; playing a night-time scenario in these simulators, with your own ambient lights turned off, is a transformative experience.

I also enjoyed spending five-and-a-half hours watching *Inception* and *Oppenheimer* with the glasses – an experience greatly enhanced by the upgraded audio system. I'd have liked more bass, but there's little else to complain about in terms of audio performance. RayNeo even includes a Whisper Mode, which cuts down on sound leakage so you don't disturb those around you.

LEFT The glasses are comfortable to wear for long periods

In all, the RayNeo Air 3s are a big step up from their predecessors. The audio upgrade is particularly significant – the difference is like night and day – but the sharper, more consistent image also helps banish any sense of compromise.

Even better, these improvements don't come with a price hike – the Air 3s are actually currently cheaper than their predecessors. Since they're not directly on sale in the UK at the moment you'll have to budget around £50 for import fees on top of the purchase price, but even then you're looking at comfortably under £300. If you're in the market for AR glasses and don't want to splash out on pricier options from Xreal or Ray-Ban, these are a bargain. **BRANDON HILL**

BELOW Each lens has a 1080p resolution and a smooth 120Hz refresh rate

SPECIFICATIONS

2 x 120Hz micro-OLED displays • 1,920 x 1,080 resolution per eye • 47° field of view • 3 DoF • 650cd/m² peak brightness • 4 x microspeakers • 170 x 147 x 48mm (WDH) • 76g • 1yr warranty

Google Pixel 9a

Quite simply the best mid-range phone around, with useful AI features, long battery life and excellent cameras

PC PRO A-LIST

SCORE ★★★★★

PRICE 128GB, £416 (£499 inc VAT)
from store.google.com

For a long time Google was untouchable when it came to mid-price phones, but recent newcomers such as the £449 Nothing Phone 3a Pro (*see issue 368, p76*) and Apple's £599 iPhone 16e (*see issue 368, p72*) have put it under pressure. But not for long. Google reclaims the crown thanks to powerful AI features and competitive pricing.

The Pixel 9a comes in four chic colours – Iris, Obsidian, Peony and Porcelain – although it lacks the character of previous models. That's because Google has replaced the distinctive camera bar with a smaller, more conventional bump. You may appreciate the simpler look, but I miss such a key part of the Pixel's identity.

Other changes are subjective, too, such as the flat sides and rounded corners; if it weren't for the dual cameras on the back, the Pixel 9a would look an awful lot like the iPhone 16e. On the plus side, it isn't as sharp around the edges, so it's nicer to hold, and its aluminium frame and composite matte casing feel solid. One more big positive: an IP68 rating for water and dust resistance.

Quite the display

The Pixel 9a's 6.3in OLED screen is gorgeous, with an adaptive 120Hz refresh rate that makes animations fluid in a way the iPhone 16e's 60Hz panel can't match. Even more impressive is its stunning peak brightness of 2,076cd/m²; no other mid-range phone comes close. Colour coverage is terrific, too, with 94% of the DCI-P3 gamut in play.

On the back, the dual camera array feels positively liberating in comparison to the iPhone 16e's single sensor. The main 48MP camera has a wide f/1.7 aperture that produces bright, clean images, while the separate 13MP ultrawide lets you effortlessly take in more of the scene.

Shots taken on the main camera compare favourably to those on the iPhone 16e. Detail levels are similar – which is to say, very good – but shots from the Pixel looked more natural in tone, while the iPhone tended to oversaturate reds and oranges.

The 9a also gains a new macro focus mode, which leans on AI to enhance and process close-ups, and, as with the Pixel 8a, it's great to see Night Sight on an A-series phone. The iPhone 16e does very well at picking out detail in almost pitch-dark conditions, but the Pixel 9a brightens up more of the shadows, resulting in a better-balanced overall picture.

ABOVE Google's latest phone is the best you can buy for the money

The one area where the iPhone 16e beats the Pixel 9a is long-range zooming. Neither phone uses an optical zoom, instead relying on digital zoom and cropping into the sensor, and up to around 5x zoom there's not much to choose between them. As I got close to the maximum 8x zoom, though, I found the Pixel's image processing wasn't as effective as Apple's when it came to interpolating clean detail.

"The Pixel 9a reclaims the mid-range crown thanks to strong hardware, powerful AI features and competitive pricing"

In terms of AI assistance, the Pixel 9a benefits from most of the same tools as Google's high-end

BELOW The Pixel 9a comes in four chic colours

phones, including Add Me, Audio Magic Eraser, Magic Editor and Best Take, to help you get the best possible results. And on the video side the Pixel 9a should meet almost anyone's needs, with 4K recording at up to 60fps and a slow-motion mode that shoots 1080p footage at 240fps.

Tensor strength

The Pixel 9a uses the same Tensor G4 processor as the Pixel 9 and 9 Pro, so in effect it's a premium-performance handset. Although it has only half as much RAM as my Pixel 9 Pro XL, I couldn't feel any difference between the two handsets in everyday tasks.

Benchmark tests confirm that the 9a performs very similarly to the Pixel 9, with Geekbench 6 scores of 1,707 and 4,512 in the single-core and multicore tests respectively. However, as is usual with Google's Tensor chips, number-crunching power is nowhere near a match for Apple, with the iPhone 16e scoring 3,328 and 8,132 in the same tests.

Likewise, the Pixel 9a can't keep up with the iPhone 16e's graphical performance, achieving an average frame rate of 57fps in the 3DMark Wild Life Original Unlimited test, versus 71fps for the iPhone 16e. Unless you're a die-hard gamer, though, I wouldn't worry: I couldn't spot any significant difference in graphically intensive games such as *Modern Combat* and *Age of Origins*. If anything, they look smoother on the Pixel 9a thanks to the screen's higher refresh rate.

Genuinely good AI

The Pixel 9a's AI features extend well beyond the camera, incorporating most of the capabilities of Google's premium phones, which are considerably more advanced and practical than the Apple Intelligence features you get with the iPhone 16e. For example, Apple has nothing close to Google's Call Screen feature, which takes calls when you're busy, and even offers contextual responses you can choose while "screening" the call.

I also love the way that the Gemini Live interactive assistant now works with the camera. I tried pointing it at a hallway in my home and asking what kind of artwork I should hang; to my amazement, not only did Gemini Live give me aesthetic advice, it analysed the setting, detected that most of the lighting comes from a window in an adjacent room and recommended installing track lights to better display the artwork. The Pixel 9's AI capabilities are already one of its greatest selling points, and you can expect them to become better and smarter over time thanks to a full seven years of software support.

It's worth noting that the Pixel 9a doesn't include everything that's in high-end Pixel handsets. Right now there are two specific AI features unavailable to the 9a, namely Pixel Screenshots and Call Notes. The former lets you store, organise and search saved screenshots, which I don't miss. However, I do find Call Notes tremendously useful for automatically generating searchable transcripts of my phone calls.

What's more, while the Pixel 9a boasts the now-standard Gemini AI assistant, it comes with only one month of access to Gemini Advanced, not the full year offered with the Pixel 9 Pro and 9 Pro XL. After that it's a steep £19 a month for Google's premium AI service.

A star is born

The Pixel 9a comes with a 5,100mAh battery that got me through a full working day without worries. In our battery benchmark test it lasted an average of 13hrs 8mins on a full charge – well up from the old Pixel 8a's time of 11hrs 21mins in the same test. It also beats the iPhone 16e, which lasted 12hrs 41mins, although the budget longevity champion remains the Nothing Phone 3a on 15hrs 25mins.

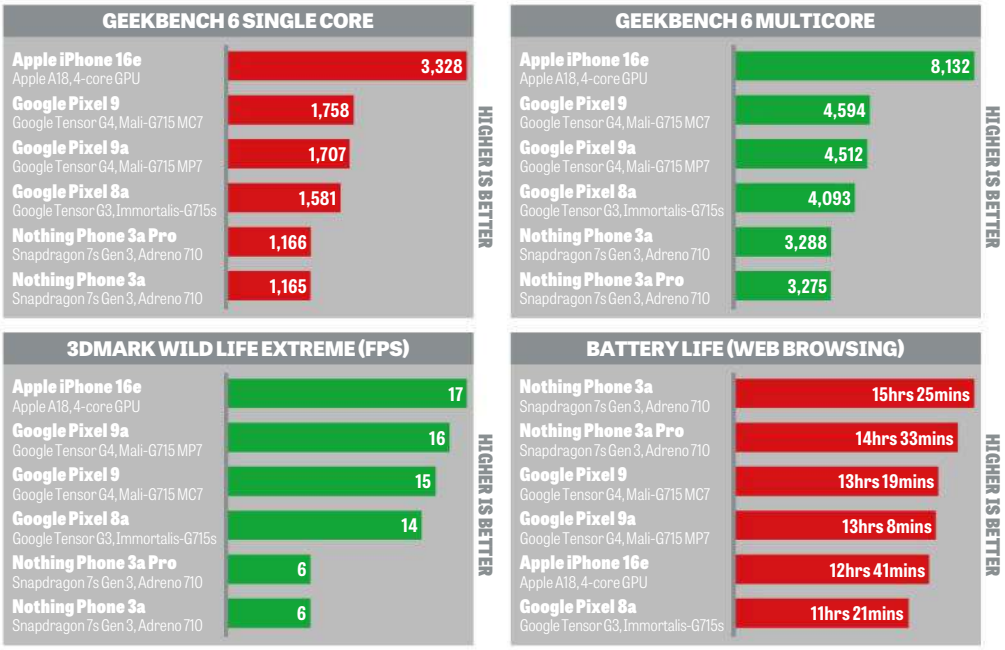
"The AI features give the Google Pixel 9a a huge advantage over its rivals, particularly the more expensive iPhone 16e"

Wired recharging is supported at a maximum of 23W, and with a high-power supply I found 15 minutes of charging took the battery from empty to 25%, reaching 47% after half an hour. Wireless charging, however, remains stuck at a leisurely 7.5W, so it will take a good few hours to fully recharge on a pad.

So, should you buy the Google Pixel 9a? If you're focused on cost, take a look at the £329 Nothing Phone 3a (*see issue 368, p77*) alongside its Pro brother: both give you a lot for lower prices. However, the AI features of the Pixel 9a give it a huge advantage over its rivals, particularly the more expensive iPhone 16e.

Taking value for money into account – alongside factors such as performance, screen quality, features and support – the Pixel 9a isn't simply the best mid-range phone around, but arguably the best all-round smartphone of 2025. **JOHN VELASCO**

BELOW Games look silky smooth thanks to a 120Hz refresh rate



SPECIFICATIONS

8-core Google Tensor G4 processor • 8GB RAM • Mali-G715 MP7 graphics • 6.3in 120Hz P-OLED screen, 1,080 x 2,424 resolution • 5G • 128GB/256GB storage • IP68 rating • dual 48MP/13MP rear cameras • 13MP front camera • Wi-Fi 6E • Bluetooth 5.3 • NFC • 5,100mAh battery • USB-C 3.2 Gen 1 • Android 15 (7 major updates) • 73 x 8.9 x 155mm (WDH) • 186g • 1yr warranty

Xiaomi 15

A solid Android phone with few flaws, but unlike the Xiaomi 15 Ultra it fails to stand out from the crowd

SCORE ★★★★☆

PRICE 256GB, £749 (£899 inc VAT) **from** mi.com

Last month we were impressed by Xiaomi's new flagship phone, the Xiaomi 15 Ultra (*see issue 368, p74*). Now comes the regular Xiaomi 15, offering a similar feel and features for a lower price.

It starts at £899 for 256GB of storage, while the larger 512GB option comes in at £999. That's more expensive than the Samsung Galaxy S25 (*see issue 367, p70*), which costs £859 for 256GB and £959 for 512GB, but it's telling that the iPhone 16 (*see issue 363, p68*) costs £799 for 128GB, £899 for 256GB and an intake-of-breath-worthy £1,099 for 512GB.

Xiaomi's display is a fraction larger at 6.4in, and this AMOLED panel packs a 1,200 x 2,670 resolution and dynamic 120Hz refresh rate. Xiaomi claims a brightness of up to 3,200cd/m², and support for HDR10+ and Dolby Vision too, but what matters is that in use it looks great.

Less great to look at: the big square camera bump on the rear, which isn't as elegant as the round camera unit on the Ultra. But it contains a fine set of hardware – a standard main lens, an ultrawide-angle shooter and a 2.6x telephoto lens, each with a 50MP resolution and tuned with Leica optics.

To see what the cameras are capable of, I put the Xiaomi 15 head to head with one of the best Android camera phones on the market, namely the Google Pixel 9 Pro (*see issue 362, p58*). The two phones have quite different characters: a sunset photo from the Xiaomi 15's main camera came out crisper than the Pixel 9 Pro's, but Google's image had a warmer, more orange look. In all, Xiaomi's image was more true to life, but also less vibrant.

Switching to telephoto mode, the Xiaomi 15 was again cooler but this time lacked detail compared to its tough rival: distant footprints in the dirt were less well defined than in the Pixel version, while a tower in the distance looked blurrier. And if I wanted to get really close up, the Pixel was a clear winner thanks to its 5x optical zoom.

The Xiaomi's 32MP front camera turns out clean, bright selfies, with nicely controlled background blur in Portrait mode – although I hate the way that facial smoothing is enabled by default. Overall, the Xiaomi 15 doesn't really challenge the Pixel 9 Pro in the way the Ultra does, but it's great for everyday snaps.

Like most top Android phones, the Xiaomi 15 is powered by the Snapdragon 8 Elite chipset, and in all UK models this is partnered with 12GB of RAM. However, the unit I tested had 16GB of RAM, giving it the same core specification as the Xiaomi 15 Ultra.

In benchmarks, this handset finished slightly behind the 15 Ultra in Geekbench 6's single-core benchmarking test, with an average score of 2,972. In the multicore test it actually achieved a slightly better score of 9,330 than the Ultra's 9,064; while that might sound like a blip, the Xiaomi 15 also beat the supposedly overclocked Samsung Galaxy S25.

Graphics performance was again better than expected. With an average frame rate of 44fps in the 3D Mark Solar Bay Unlimited benchmark, the Xiaomi 15 beat every other phone I compared it to, although the Galaxy S25 came very close with 43fps.

Battery life is another strength. In our YouTube test, the Xiaomi 15's battery meter dropped by only 10% in three hours of video playback; for comparison, the Pixel 9 Pro suffered a 21% loss, and Xiaomi's own 15 Ultra dropped by 11%, presumably thanks to its larger screen. For very fast recharging you can use Xiaomi's 90W HyperCharge charger – but you'll have to buy it yourself, as there's no power supply in the box. With my own 67W supply I was impressed to see the Xiaomi 15 charge from zero to 46% in 15 minutes, and to 81% by the 30-minute mark.

ABOVE The Xiaomi 15 performs better than many of its rivals

LEFT The camera bump on the rear lacks the elegance of the Xiaomi 15 Ultra's

Xiaomi's HyperOS 2 software is based on Android 15 but adds numerous iOS-like touches, including a blatant clone of the Apple Control Centre. All major new features in this release revolve, of course, around AI, and as usual performance is hit and miss. For example, the AI subtitling feature did an amazing job of translating a live feed of Spanish news, but attempting to watch *Squid Game* in the original Korean resulted in a garbled mess. And when I tried to use the AI Erase function on my photos, the phone often simply replaced a selected object with a slightly smaller one.

AI expansion was more successful, especially with simple textures such as grass, and the feature for removing reflections from photos shot through glass worked better than I'd expected. I was also impressed by the tool that adjusts the tone of the sky and then corrects the colour cast of the rest of the photo to match. New features will hopefully arrive courtesy of a promised four generations of system updates, as well as six years of security updates; while Google and Samsung offer seven years of both for their premium devices, that's not a bad lifespan.

The Xiaomi 15 isn't the best Android phone you can buy, but it has no major weaknesses, and offers great battery life, premier-league performance and a solid set of cameras. If you're a fan of Xiaomi's Apple-style HyperOS, you'll have no complaints.

TOM PRITCHARD

"It has no major weaknesses, and offers great battery life, premier-league performance and a solid set of cameras"

LEFT It may look inelegant, but the triple cameras take pretty good shots

SPECIFICATIONS

8-core 4.3GHz/3.5GHz Qualcomm Snapdragon 8 Elite SoC • 12GB RAM • Adreno 830 graphics • 6.4in 120Hz AMOLED screen, 1,200 x 2,670 resolution • 5G • 256GB/512GB storage • dual nano-SIM • IP68 • triple 50MP/50MP/50MP rear cameras • 32MP front camera • Wi-Fi 7 • Bluetooth 6 • NFC • 5,240mAh battery • USB-C 3.2 Gen 2 connector • Android 15 (4 major updates) • 71 x 8.1 x 152mm (WDH) • 189g • 2yr RTB warranty

Samsung Galaxy A56 5G Enterprise Edition

A well-built big-screen phone enhanced with Galaxy AI, but don't expect heaps of business-friendly extras

SCORE ★★★★☆

PRICE £383 (£459 inc VAT) from samsung.com

When it comes to phones, the letter "a" has been hijacked as a shortcut for affordable. So it is for Google's Pixel 9a (*see p74*), and so too for Samsung's long line of A-series phones. These have now all been refreshed for 2025, from the bottom-of-the-pack A16 for £139 to this top-of-the-range A56.

I'm testing the Enterprise Edition, which costs £40 less than the non-Enterprise model but includes 128GB of storage rather than 256GB. There are two other differences between this and the consumer version. First, you'll enjoy three years of support rather than two, plus the promise of next-day business exchange with a "gold stock" phone. I assume that means either new or refurbished, but Samsung is unclear despite my pestering. Businesses can also take advantage of Samsung's Knox suite of security software, which allows IT teams to remotely manage devices – whether that's enforcing policies or wiping data if the phone is lost or stolen.

Samsung isn't alone in producing these easier-to-manage business variants. You can supposedly buy the Moto G75 5G Business Edition for £275 from Vodafone or BT (it doesn't appear in searches, so good luck), while Lenovo-leaning companies should consider the ThinkPhone 25 by Motorola (*see issue 365, p71*). This is a few pounds cheaper than the A56, but also has the advantage of being more compact – surely a nice characteristic for what is likely to be a second phone.

But there are good reasons to commit to the A56 as your main phone, not least that it has space for two nano-SIMs so you can juggle accounts. It also features a generous 6.7in AMOLED panel which – and this shouldn't be a surprise – performed well in our tests. In Vivid mode it covered 84% of the DCI-P3 space with an average Delta E of 0.9, while its Natural mode ties almost perfectly to the sRGB space, albeit with weaker accuracy as its average Delta E was 2.94.

I'd stick with Vivid mode due to its poppier colours, plus the fact it peaks at 425cd/m² in non-adaptive mode rather than 355cd/m² for Natural. Either way, so long as I switched on adaptive brightness, I had no problems reading the screen in the sun's full glare; here, Samsung claims brightness goes as high as 1,200cd/m².

The screen's final plus points: a smooth 120Hz refresh rate and a sharp 385dpi thanks to a 1,080 x 2,340 resolution. Paying more for a higher resolution doesn't make sense to me, as your eyes simply aren't good enough to notice it.

You also benefit from a solid set of stereo speakers. I was more than happy listening to music on the A56, as it only struggled when playing subtle, multi-layered tracks (audio became jumbled).

I was relieved to find that Samsung isn't pushing its AI here. You can access features such as Google's Circle to Search, AI Select (this makes it easy, say, to capture footage from a YouTube video and turn it into a GIF) and Read Aloud (while on a web page), but you must seek them out. For example, AI Select is hidden away in the Edge bar – you swipe from the panel's top right edge to make it appear – so it won't get in your way.

ABOVE The glorious 6.7in AMOLED screen is up to Samsung's usual high standards

ABOVE The three rear cameras include a 12MP super-wide-angle lens

Despite these advanced features, the A56 never feels slow. It's based on Samsung's own Exynos 1580 chip, which uses the later ARMv9 cores and one extremely powerful 2.9GHz Cortex-A720 core. It's a solid improvement over the Exynos 1570 chip in the A55, and that showed in our benchmarks: it returned 1,365 and 3,879 in Geekbench 6 compared to 1,155/3,468 for the A55 and 1,050/2,998 for the ThinkPhone. But the Pixel 9a was faster still, scoring 1,707/4,512. That lead extended further in 3DMark Wild Life Original, with the A56 returning 4,804 (29fps) to the Pixel's 9,592 (57fps).

Samsung doesn't go overboard with cameras, but you still get a trio of solid offerings. You'll likely use the 50MP wide-angle camera the most, and this captures well-balanced images in bright conditions and indoors. There's no optical zoom, but by default Samsung captures 12MP images from the 50MP sensor, which means you can (to an extent) zoom in without losing detail. There's a handy 12MP super-wide-angle camera for landscapes, but I question the point of the 5MP macro as its colours are off. Selfies and videos on the other hand are excellent, with optical stabilisation and 4K/30fps or 1080p/60fps.

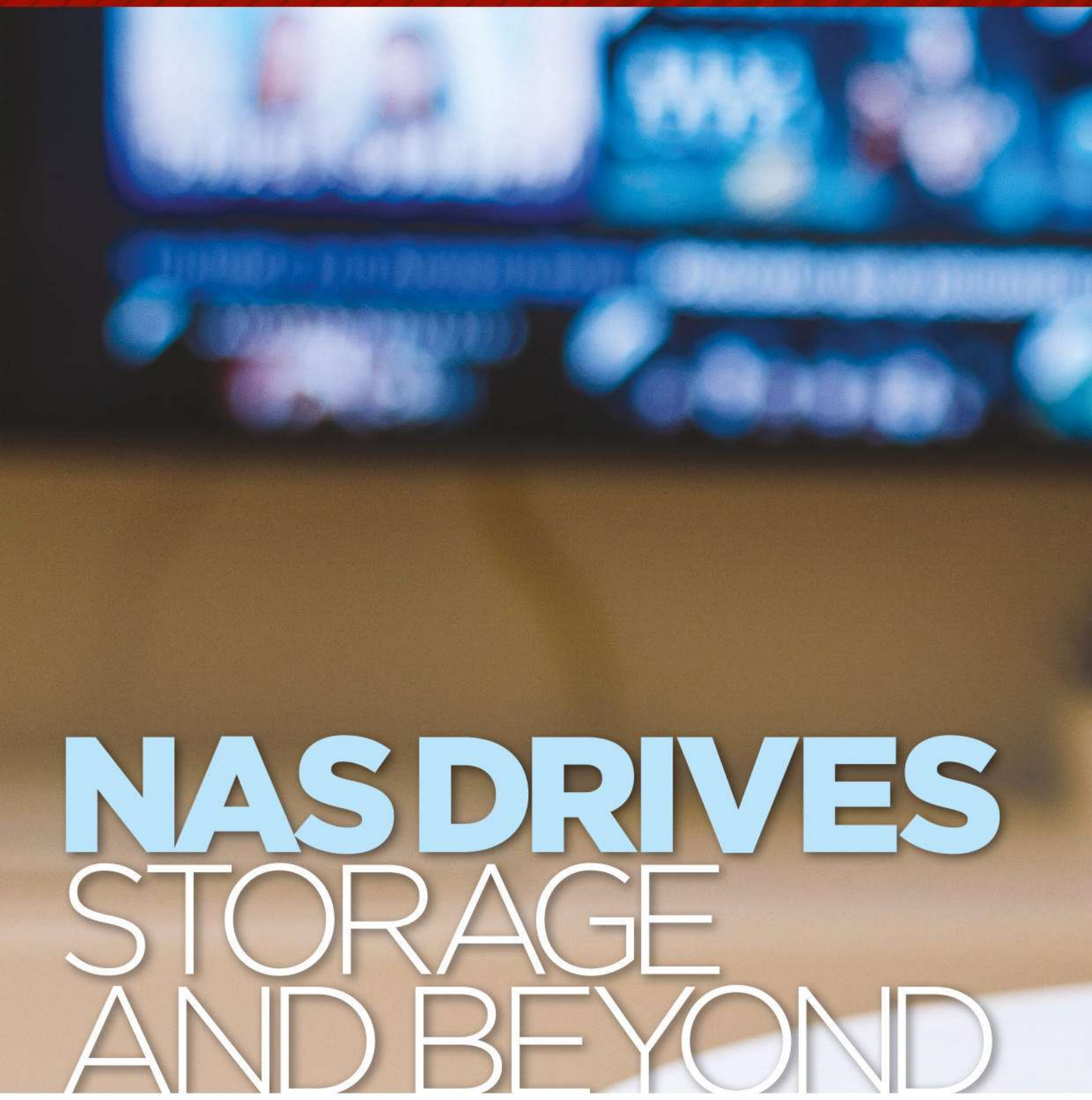
So, should you buy this for personal use (£499 for a 256GB edition) or for business rollouts? The first question is easier: the Pixel 9a has the clear edge. For business use, size is an issue. The A56 5G is taller and wider than the ThinkPhone 25, and I noticed that in my pocket. This aside, the Samsung's superior cameras, performance, AI skills and OS updates – six years rather than five – give it the advantage. Especially as it should last the course, with IP67 resistance and Gorilla Glass Victus to protect that glorious screen. **TIM DANTON**

"There are good reasons to commit to the A56 as your main phone, not least that it has space for two nano-SIMs so you can juggle accounts"

LEFT Six OS updates and an IP67 rating mean the A56 should last a good while

SPECIFICATIONS

8-core 2.9GHz/2.6GHz/1.9GHz Samsung Exynos 1580 SoC • 8GB RAM • Xclipse 540 graphics • 6.7in 120Hz AMOLED screen, 1,080 x 2,340 resolution • 5G • 128GB storage • dual nano-SIM • IP67 • triple 50MP/12MP/5MP rear cameras • 12MP front camera • Wi-Fi 6 • Bluetooth 5.3 • NFC • 5,000mAh battery • USB-C 2 connector • Android 15 with OneUI 7 (6 major updates) • 78 x 7.4 x 162mm (WDH) • 198g • 2yr RTB warranty



NAS DRIVES STORAGE AND BEYOND

With our guide to the best NAS devices currently available, you can take control of your files and run your own private cloud

Despite cloud storage's prevalence and ubiquity, the humble network-attached storage (NAS) device is still an attractive proposition. Two obvious reasons are space and money.

While 1TB of cloud storage may seem like a lot and can be picked up relatively cheaply (or even bundled with a Microsoft 365 plan), it's an ongoing cost, and that storage space isn't as much as you might think.

Fill it up with your music collection, every file you've owned and a load of videos, and 1TB disappears quickly. With your own NAS, you're master of your storage needs and can start with a lot more storage than you get online, even with an entry-level device.

A NAS is about more than just physical storage, though. It's a way of controlling what you own without paying for the privilege. Thanks to the apps that Asustor, Qnap, Synology and TerraMaster provide, you can still enjoy the effects of a Dropbox-like system, but your data is synchronised to your own server.

A NAS device is also multifunctional. Additional apps can turn it into a web server or a UPnP server for your music. Install Plex, and you can

stream any videos and films you've stored digitally, making your version of Netflix with content you own and with no monthly cost.

Buy the right kinds of security cameras, and you can stream and store security footage to your NAS, giving you way more storage than any cloud system. Did someone say Ring?

Whether these features sound interesting or you want a large bucket of storage for backups, this comprehensive review of NAS devices will help you find the right device for your needs.

CONTRIBUTOR David Ludlow

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			RECOMMENDED		LABS WINNER
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	Asustor Drivestor 2 Pro AS3302T	Qnap TS-233	Qnap TS-264	Synology DiskStation DS723+	Asustor Nimbustor 4 Gen2 AS5404T
Price and supplier					
Rating	4 stars	3 stars	4 stars	4 stars	5 stars
Model number	AS3302T	TS-233	TS-264	DS723+	AS5404T
Price as reviewed[1]	£192 (£230 inc VAT)	£168 (£202 inc VAT)	£391 (£469 inc VAT)	£389 (£467 inc VAT)	£441 (£529 inc VAT)
Supplier	amazon.co.uk	ukstore.qnap.com	ukstore.qnap.com	amazon.co.uk	amazon.co.uk
Manufacturer's website	asustor.com	qnap.com	qnap.com	synology.com	asustor.com
Warranty	3yr	2yr	3yr	3yr	3yr
Storage specifications					
Type	Barebones NAS	Barebones NAS	Barebones NAS	Barebones NAS	Barebones NAS
SATA drives	2 (3.5in or 2.5in)	2 (3.5in or 2.5in)	2 (3.5in or 2.5in)	2 (3.5in or 2.5in)	4 (3.5in or 2.5in)
M.2 drives	✗	✗	2 (NVMe PCIe Gen 3)	2 (NVMe PCIe Gen 3)	4 (NVMe PCIe Gen 3)
Other drives	✗	✗	✗	✗	✗
RAID support	RAID0, RAID1, JBOD	RAID0, RAID1, JBOD	RAID0, RAID1, JBOD	RAID0, RAID1, JBOD, SHR	RAID0, RAID1, RAID5, RAID6, RAID10, JBOD
Claimed max read speed	216MB/sec	114MB/sec	589MB/sec	475MB/sec	599MB/sec
Claimed max write speed	275MB/sec	103MB/sec	589MB/sec	225MB/sec	599MB/sec
Hardware encryption	✗	Accelerated	Accelerated	Yes	✗
Core specifications					
CPU name	Realtek TRD1296	Not specified	Intel Celeron N5095	AMD Ryzen R1600	Intel Celeron N5105
CPU cores	4 (Cortex-A53)	4 (Cortex-A55)	4 (Jasper Lake)	2 (Zen)	4 (Jasper Lake)
CPU base speed	1.4GHz	2GHz	2GHz	2.6GHz	2GHz
Supplied RAM	2GB	2GB	8GB	2GB	4GB
Maximum RAM	2GB	2GB	16GB	32GB	16GB
Physical design					
Ethernet ports	1 x 2.5GbE	1 x 1GbE	2 x 2.5GbE	2 x 1GbE	2 x 2.5GbE
USB-A 2 ports	✗	2	2	✗	✗
USB-A 3.2 ports	3 (Gen 1, 5Gbits/sec)	1 (Gen 1, 5Gbits/sec)	2 (Gen 2, 10Gbits/sec)	1 (Gen 1, 5Gbits/sec)	3 (Gen 2, 10Gbits/sec)
USB-C 3.2 ports	✗	✗	✗	✗	✗
Expansion options	Additional drives via USB	Additional drives via USB	2 x PCIe Gen 3 slots supporting 10GbE or 2 x QM2 NVMe expansion cards, multiple tower and rack-mount expansion enclosures	PCIe Gen 3 x2 network upgrade slot, eSATA port	AS6004U HDD expansion via USB
Dimensions (WDH)	170 x 114 x 230mm	92 x 158 x 186mm	105 x 165 x 227mm	106 x 223 x 166mm	174 x 230 x 170mm
Extras					
Bundled software	Download Center, Looks Good, Photo Gallery 3, Surveillance Center	Qsync Central, Download Station, Photo Station, Video Station	Qsync Central, Download Station, Photo Station, Video Station	Synology Drive, Synology Surveillance Station, Synology Office, Synology Photo	Download Center, Looks Good, Photo Gallery 3, Surveillance Center
Supplied accessories	1 x Cat5e cable	2 x Cat5e cables	2 x Cat5e cables	2 x Cat5e cables	2 x Cat5e cables

[1] Prices correct at time of going to press but are subject to change

	RECOMMENDED	RECOMMENDED			RECOMMENDED
				5-BAY+ NAS DRIVES	
	Qnap TS-464	**Synology DiskStation DS923+**	**TerraMaster F4-424 Pro**	**Qnap TS-h973AX**	**Synology DiskStation DS1522+**
	★★★★☆	★★★★☆	★★★☆☆	★★★☆☆	★★★★☆
	TS-464	DS923+	F4-424 Pro	TS-h973AX	Synology DiskStation DS1522+
	£491 (£589 inc VAT)	£450 (£540 inc VAT)	£490 (£588 inc VAT)	£666 (£799 inc VAT)	£558 (£670 inc VAT)
	ukstore.qnap.com	scan.co.uk	amazon.co.uk	ukstore.qnap.com	amazon.co.uk
	qnap.com	synology.com	terra-master.com	qnap.com	synology.com
	3yr	3yr	2yr	3yr	3yr
	Barebones NAS	Barebones NAS	Barebones NAS	Barebones NAS	Barebones NAS
	4 (3.5in or 2.5in)	4 (3.5in or 2.5in)	4 (3.5in or 2.5in)	7 (5 x 3.5in, 2 x 2.5in)	5 (3.5in and 2.5in)
	2 (NVMe PCIe Gen 3)	2 (NVMe PCIe Gen 3)	2 (NVMe PCIe Gen 3)	✗	2 (NVMe PCIe Gen 3)
	✗	✗	✗	2 x U.2 (NVMe PCIe Gen 3)	✗
	RAID0, RAID1, RAID5, RAID6, RAID10, JBOD	RAID0, RAID1, RAID5, JBOD, SHR	RAID0, RAID1, RAID5, RAID6, RAID10, JBOD	RAID0, RAID1, RAID5, RAID6, RAID10, JBOD	RAID0, RAID1, RAID5, RAID6, RAID10, SHR, JBOD
	589MB/sec	592MB/sec	283MB/sec	1,167MB/sec	736MB/sec
	589MB/sec	562MB/sec	283MB/sec	929MB/sec	796MB/sec
	Accelerated	Yes	Yes	Accelerated	✓
	Intel Celeron N5095	AMD Ryzen R1600	Intel Core i3-N305	AMD Ryzen Embedded V1500B	AMD Ryzen R1600
	4 (Jasper Lake)	2 (Zen)	8 (Alder Lake-N)	4 (Zen)	2 (Zen)
	2GHz	2.6GHz	1.8GHz	2.2GHz	2.6GHz
	8GB	4GB	32GB	8GB	8GB
	16GB	32GB	32GB	64GB	32GB
	2 x 2.5GbE	2 x 1GbE	2 x 2.5GbE	2 x 2.5GbE, 2 x 10GbE	4 x 1GbE
	2	✗	✗	✗	✗
	2 (Gen 2, 10Gbits/sec)	2 (Gen 1, 5Gbits/sec)	1 (Gen 2, 10Gbits/sec)	2 (Gen 2, 10Gbits/sec)	2 (Gen 2, 5Gbits/sec)
	✗	✗	1 (Gen 2, 10Gbits/sec)	1 (Gen 2, 10Gbits/sec)	✗
	2 x PCIe Gen 3 supporting 10GbE or 2 x QM2 NVMe expansion cards, multiple tower and rack-mount expansion enclosures	PCIe Gen 3 x2 network upgrade slot, eSATA port	Various desktop attached storage enclosures via USB	Multiple tower and rack-mount expansion enclosures	PCIe Gen 3 x2 network upgrade slot, 2 x eSATA ports
	170 x 165 x 227mm	199 x 223 x 166mm	179 x 154 x 222mm	177 x 225 x 224mm	166 x 230 x 223mm
	Qsync Central, Download Station, Photo Station, Video Station	Synology Drive, Synology Surveillance Station, Synology Office, Synology Photo	Terra Photos, TerraSync, Surveillance Manager	Qsync Central, Download Station, Photo Station, Video Station	Synology Drive, Synology Surveillance Station, Synology Office, Synology Photo
	2 x Cat5e cables	2 x Cat5e cables	1 x CAT 6 cable	2 x Cat5e cables	4 x Cat5e cables

Questions you need to ask before buying a NAS drive

There's one easy way to avoid buyer's remorse when purchasing a NAS drive, and that's to have answers to these key questions before you reach for your card

Q How many bays do I need?

Avoid single-bay NAS devices. These are effectively external hard disks with a network port. While they offer the same features as other NAS devices, they have one big problem: if the hard disk dies, all your data goes.

At the minimum, you should opt for a two-bay system. That way, you can install two hard disks and use RAID1 (mirroring), where data is written to both disks simultaneously. Should one hard disk fail, your data is safe, and you can swap the broken disk for a new one. It's worth swapping quickly to prevent the risk of complete data loss.

The downside of a two-bay NAS system is that with a RAID1 configuration you only get half the total capacity of both disks. Don't be tempted to use a different RAID configuration (*see p89*) to get more storage, as you risk losing your data.

A four-bay NAS gives you more flexibility and a wider choice of RAID modes. With three or four disks (or more if you opt for a five-bay or higher model), you can use RAID5 or a proprietary equivalent. With these RAID levels, you're protected if any one disk fails, yet also enjoy the total capacity of all disks minus one. For example, install four 1TB hard disks, and you can use 3TB of space.

ABOVE Your chosen device should come with at least two bays

At the minimum, you should go for a two-bay system. That way, you can install two hard disks and use RAID1 (mirroring)

Q Should I configure RAID for performance or data security?

With two or more disks, you can use RAID to expand the total storage by pooling multiple hard disks together. See p89 for the difference between RAID levels, but the important factor to look for is whether the RAID level you want gives you better performance, protects you from a hard disk failure or both.

Unless your data is reliably backed up elsewhere, we suggest that you implement the level of RAID that gives you the best performance while protecting you from a hard disk failure.

BELOW Many devices use NVMe SSDs, and most take M.2 SSDs

Q Do I need a NAS device that works with NVMe SSDs?

An increasing number of NAS devices will take NVMe SSDs, as popularised by modern laptops and desktop PCs. With some NAS devices, you can use NVMe drives as extra-fast storage, with the added advantage that solid-state drives are silent.

However, in most cases, NVMe drives aren't for storage but caching, speeding up how quickly files can be sent to, or read from, your NAS device. If you regularly write a lot of files to your NAS and use it more like a hard disk, then it's probably a worthy upgrade.

Most NAS devices will take M.2 2280 SSDs, but check compatibility before you buy. Also check the advised size of drives that you'll need, as this varies by the total amount of storage that you have installed. Typically, most NAS providers have this information online or via the web interface for their products, providing a list of compatible products.

In most cases, a NAS will require two NVMe drives configured as RAID1 for a read/write cache, as redundancy is required. Again, you can buy NAS-specific SSDs, such as the Western Digital Red range, which are designed to be used in the close confines of a NAS enclosure.

Q What kind of network connection should my NAS have?

A NAS device will, at minimum, have a gigabit Ethernet port. Gigabit Ethernet is pretty fast, but it tops out at around 113MB/sec. A faster Ethernet connection will pay dividends if you've got a fast hard disk or solid-state caching (or

storage), or you need to share the storage with multiple users.

Many modern NAS devices now ship with a 2.5GbE connection, which has the advantage that it will run across existing Cat5e cabling, and many new mesh Wi-Fi systems have these ports as standard.

A faster connection improves transfer speeds, provided your computer is connected via 2.5GbE or a fast Wi-Fi 7 connection. And you get more bandwidth to share between devices: with 2.5GbE, two gigabit Ethernet users will still get fast transfer speeds.

Some NAS devices can be upgraded with a 10GbE connection. This should be connected via Cat6 cabling (up to 55m) or Cat6a (up to 100m), although you should be able to run it over Cat5e over distances of up to 45m.

10GbE is becoming more common on high-end routers and mesh systems. Its main advantage is the total amount of bandwidth available. If you want a NAS for business use and have many heavy users, 10GbE may be the way to go.

It's common for many NAS devices to have two Ethernet ports. These can be used to add redundancy, so that your NAS is still online should one port fail, or to expand bandwidth by providing two connections. In a business, you could also connect each port to a different subnet.

Q What about apps?

Most modern NAS systems provide all the basic services you need right out of the box, including protocols for talking to Windows, macOS and Linux clients. They will also integrate with Apple's Time Machine backup service – you can turn this on with a click – so you can keep your Mac clients effortlessly backed up. For corporate deployments, many NAS units also support iSCSI and Active Directory, while most offer some form of remote access, both for management and for features and services.

Even so, have a browse through the apps available as these can extend the capabilities of your NAS appliance in all sorts of ways. All the units here come with an app store containing tens of additional apps. These invariably include a selection of media server apps, which allow your NAS to stream audio and video to smart devices in your home. Most apps are free, although occasionally you'll need a licence to add functionality.

In addition, you'll find business and development tools, surveillance tools that work with IP cameras, and even content management systems such as WordPress. Some even offer rivals to Google Docs. Furthermore, it's now common to find support for virtualisation through Docker.

ABOVE Many Wi-Fi mesh systems support 10GbE connections

If an app you want to use isn't listed in the store, it may be possible to install it manually, but for obvious reasons we don't recommend this unless you're confident in your technical abilities.

One caveat: you'll need a powerful NAS to run a whole load of apps and services. It's a good idea to pick one with an Intel or AMD processor. And make sure there's plenty of RAM or that you can add more. If you're unsure about how much headroom you have, there's usually an activity monitor available within the appliance's web interface, exposing what's using its CPU and RAM, so you can spot any services that might be overtaxing your hardware.

You'll need a powerful NAS to run a whole load of apps and services. It's a good idea to pick one with an Intel or AMD processor

Also bear in mind that your internet connection could limit your NAS's ability to serve web pages or provide remote access to family members or employees. Most routers and some NAS enclosures let you set rules to manage bandwidth, but it's worth taking into consideration.

Q Can I access my files remotely?

It used to be hard to set up secure remote access to your NAS, but these days every manufacturer makes it simple to find and connect to your server. This could prove to be a tremendously useful alternative to cloud services such as Dropbox and Google Drive, with no monthly fees and a lot more storage. It could also reduce your environmental impact, particularly if your NAS runs on a green energy source such as solar power.

Many providers offer some degree of integration with third-party cloud services, so – for example – you can easily ensure that the files in a certain folder on your NAS appliance are synchronised with your Dropbox or Google Drive account. This can be handy if your home or office printer supports the same service, as it saves you having to mess around manually moving files back and forth.

BELOW Apps can extend your NAS device's capabilities in all sorts of ways

Q What do I need to know about security?

The first thing to remember is that even with data redundancy, RAID isn't infallible. Your NAS could be fried in a fire or stolen in a break-in. It's a good idea to consider an offsite backup; many NAS systems come with integrated support for systems such as Amazon S3 or ElephantDrive, which will store very large amounts of data for a (comparatively) modest monthly fee.

Alternatively, if you have access to a NAS appliance in a second location, most units will let you replicate your data over the internet, using either the industry-standard rsync utility or a bespoke service.

Remember that a modern NAS is in effect a fully featured computer, which may be susceptible to online attacks. You should install system updates as soon as possible – most NAS devices can be set to do this automatically in the middle of the night.

Make sure your apps and services are up to date, too: platforms such as WordPress are frequently exploited by hackers. Finally, don't forget that your NAS's on-board security can't protect you from malware that's running on a PC and abusing your credentials to tamper with your data. Some ransomware specifically targets NAS appliances. The best defence is to make sure your clients are properly patched and virus-free, but we also recommend you configure snapshot protection, which is widely available if you format with the Btrfs file system.

Asustor Drivestor 2 Pro AS3302T

Although relatively cheap, this two-bay NAS has the performance and features to match high-end enclosures

SCORE ★★★★☆

PRICE £192 (£230 inc VAT) from amazon.co.uk

Although an entry-level two-bay NAS enclosure, the Asustor Drivestor 2 Pro AS3302T punches above its weight, delivering a level of performance that puts it above its budget rivals. The slight lack of upgradability will put off those who want more from their NAS device, but if you have more basic needs, this is an excellent device.

The two SATA hard disk bays are hidden behind a magnetic panel on the front. There are no locks on the drive caddies, but the panel will at least stop the casual fiddler from messing with running hard disks.

Both drive bays use a screwless design, so you can quickly pop the disks in and have the NAS ready to go in a matter of minutes. We did struggle with the hard disk clips, which are tough to remove, and had to resort to a screwdriver to pry them free.

There are screws at the back to get inside; not that you'll need to, as there are no M.2 slots for SSDs, and the 2GB of RAM is fixed and non-upgradable.

That doesn't sound like a lot of RAM, but the quad-core Realtek RTD1296 Arm CPU is efficient and doesn't need more memory for day-to-day use. However, if you want to run a lot of apps, it makes sense to buy a NAS with more RAM or the ability to upgrade.

We'd expect a NAS at this price to ship with a gigabit Ethernet port, but the AS3302T has a 2.5GbE port at the back. Gigabit Ethernet tops out at slower-than-hard-disk speeds, while a 2.5GbE port lets you maximise the disks you install. There's just a single Ethernet port here, which is fine for home use but means businesses should approach with caution.

Although there are two storage bays, the AS3302T is technically expandable to 14 bays with USB-A expansion ports via three 5Gbits/sec USB 3.2 Gen 1 ports. Realistically, if you need more storage, you'll want to buy a NAS with more bays from the start.

The AS3302T runs Asustor's ADM operating system, which is easy to use and fully featured. It was quick to set up our NAS with a RAID1 array and then create a shared folder for access. If you want apps, Asustor App Central is great, with hundreds of apps to choose from, covering everything from networking, camera surveillance, media streaming and file synchronisation. There's even onboard 4K transcoding, available through the LooksGood media player, which shows what the Arm chip is capable of.

With EZ-Connect, which requires an Asustor ID, you can easily connect remotely to the NAS from outside of your home network, which makes it much simpler to get some of the apps working.

Asustor claims a blistering 216MB/sec read speed and a 275MB/sec write speed for the AS3302T, which should put it above other two-bay NAS enclosures without SSD caching.

Indeed, this proved a very fast two-bay NAS in most of our tests, only struggling in the ATTO 4K benchmark, recording a write speed of 16MB/sec and a read speed of 21MB/sec. This could be due to the combination of lightweight processor and relatively small amount of RAM.

With larger files, things improve a lot, with the Drivestor 2 Pro AS3302T recording write speeds of 231MB/sec and read speeds of 196MB/sec in the ATTO 2MB benchmark. Here, the 2.5GbE connection allows the NAS to surpass the speeds of the enclosures that have only a 1GbE connection.

In our real-world file copy tests, the Asustor Drivestor 2 Pro AS3302T managed write speeds of 134MB/sec and read speeds of 125MB/sec. That's behind the absolute best in this test, dominated by those with four bays, but still faster than any enclosure with only a 1GbE port. Notably, the Asustor Drivestor 2 Pro AS3302T was generally faster in all our tests than its nearest competitor, the Qnap TS-233.

Overall, that makes the AS3302T the best choice for anyone who wants an entry-level two-disk NAS. The combination of price, performance and app choice is hard to beat.

This NAS does tend to top out with its transfer rates earlier than the four-bay devices that we've reviewed, and the 2GB of fixed RAM will get eaten up quickly if you want to run a lot of apps. For a small business, you'll probably want something with more resources; for home use, it's a bargain.

ABOVE The two SATA hard disk bays are hidden behind a panel

LEFT The rear 2.5GbE port is a pleasant surprise at this price

BELOW Asustor's app store is packed with useful software

Qnap TS-233

A simple, cheap, two-bay NAS, the TS-233 is good for basic needs but lags behind in terms of performance

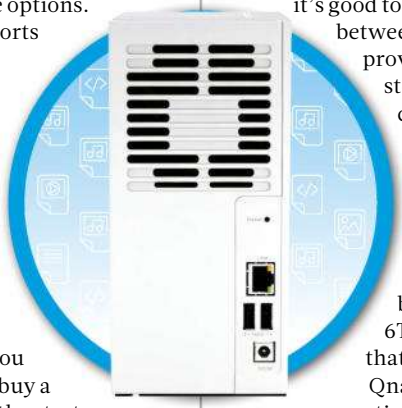
SCORE ★★★☆☆

PRICE £168 (£202 inc VAT)
from ukstore.qnap.com

The first sign of this NAS drive's low price comes when you want to open it. While most NAS enclosures here are screw-free, Qnap's TS-233 isn't. Before you can install the hard disks, the bottom screw has to be removed, and then the case side removed. That's easier said than done, and we had to consult the manual as the side didn't want to budge at first.

Once open, you'll find two hard disk caddies that unclip and slide out. SATA hard disks can then be clipped in (fortunately, no screws are needed here) and then you simply slide the caddies back into place.

With the side open, it's clear that there are no further expansion opportunities: the Qnap TS-233 can't have its memory upgraded and doesn't have any M.2 slots for adding NVMe drives. Not that this NAS device is devoid of upgrade options. With three USB-A ports (two USB 2 and one USB 3.2 Gen 1), the Qnap TS-233 is technically compatible with Qnap's USB disk enclosures. However, the TS-233's USB ports and processor speed will limit what's possible; if you need more storage, buy a four-bay NAS from the start.



Internally, there's a simple four-core Arm Cortex-A55 processor and 2GB of non-expandable RAM. This CPU was launched back in 2017 and is a budget-friendly option. It will slightly limit what you can do with this NAS device. If you want to run lots of apps, then a NAS with a faster processor and more memory (or the option to upgrade) will be required. Similarly, the single gigabit Ethernet port at the rear limits the maximum transfer speeds that this NAS device can achieve, and there's no way to get a faster network connection.

All that said, the TS-233 is relatively quick and easy to get running. Once the hard disks are installed and the NAS powered on, the Qfinder Pro app can be used to detect it and connect to the management interface. This runs through a quick wizard to install the Qnap QTS operating system.

It's a decent OS, but it lags behind Synology DSM in terms of ease of use, with a more techie feel. That's clear when creating a storage pool. While it's good to have a choice between thick and thin provisioning, it's a steeper learning curve to get the right kind of storage pool. We opted for thick provisioning, using RAID1 to mirror data between the two 6TB WD Red drives that we were using.

Qnap now offers Qtier as an option. This puts cold, less-used data onto slow storage and says it uses fast SSD storage for hot data. That sounds nice in theory, but as the Qnap TS-233 doesn't have any SSD slots, we couldn't use the option.

Qnap has a fully loaded AppCenter with many add-ons available. For example, it's well worth turning on myQnapcloud to make it easy to connect to your NAS over the internet so that many of the apps will work properly. QSync is Dropbox-like file synchronisation software with clients for Windows, Mac, iOS and Android. While Qnap doesn't have its own office software, it can be integrated with Office Online for file editing.

QVR Pro gives you surveillance camera recording, while QVR Face Insight adds an additional tool for facial recognition. There's also a wide range of media applications, including Plex, and photo, music and video servers. You'll also find the likes of WordPress, McAfee Antivirus and a range of backup software. Synology is slightly ahead in terms of apps, but Qnap covers a lot of the same ground.

Performance is predictably mixed. In the ATTO small file tests, the system was quite slow, managing 18MB/sec in the write test and 16MB/sec in the read test. It did better with larger file sizes, topping out at close to the maximum speed that gigabit Ethernet offers in the 2MB test.

In the real-world file backup test, we saw write speeds of 62MB/sec and read speeds of 79MB/sec, putting this product at the bottom of the performance table. As there's no SSD storage option, there's no chance to improve speeds.

If you're looking for a cheap and easy-to-use NAS, the Qnap TS-233 is a good but basic choice. Spend a little bit more on the Asustor Drivestor 2 Pro AS3302T, however, and you get similar features but better overall performance.

ABOVE The TS-233 is a basic NAS, with no room for expansion

LEFT A single gigabit Ethernet port will limit transfer speeds

BELOW Qnap's QTS isn't as user-friendly as other OSes

Qnap TS-264

This two-bay model offers a strong combination of price, performance and flexibility via slots for future upgrades

SCORE ★★★★½

PRICE £391 (£469 inc VAT)
from ukstore.qnap.com

The Qnap TS-264 is aimed at those who want a bit more from a traditional two-bay NAS. It's effectively the two-bay version of the excellent four-bay TS-464 that we review on p89; the latter is worth buying if you know you need more storage from the off.

Aside from having half the bays of its big brother, the TS-264 has many of the same benefits, including the dual 2.5GbE ports at the rear, which open the NAS up to faster transfer rates. If you want more, a PCIe Gen 3 x2 slot lies empty, ready and waiting for a dual-port 10GbE card.

There's a powerful 4-core Intel Celeron N5095 processor inside, which is paired with 8GB of DDR4 RAM. If you want to run more apps, you can add another stick of SODIMM RAM to upgrade the memory to 16GB.

As with the TS-464, the SATA hard disk bays are accessible from the front. A front panel has a simple slide lock on it, preventing anyone from accidentally pulling a disk out. Once this panel is off, hard disks can be installed tool-free.

If you want to use the dual M.2 NVMe slots, you will have to get a screwdriver out to remove the top panel. We prefer the more straightforward Synology approach, where M.2 slots can be accessed without any tools. While the four-bay version offers more flexibility in terms of RAID levels (with two bays, you get RAID0 or the preferred RAID1), it's good to have the option of using the NVMe drives as either a separate storage pool or for caching.

ABOVE **The TS-264 is great value and a fine performer**

BELOW **Dual 2.5GbE slots means file transfers are rapid**

The Qnap QTS is a powerful and flexible operating system, even if it feels less friendly than Synology DSM. The range of apps is enormous, with choices from media streaming to security camera surveillance.

Performance from the TS-264 is just a little behind the TS-464 when using hard disks, as two drives in a RAID1 array are slower than four disks in a RAID5 array. Adding SSD caching to the TS-262 improved rates slightly. Our best results showed the TS-262 managed decent performance in the ATTO 4KB file test, with 29MB/sec read and 34MB/sec write speeds.

With the larger 2MB file test, the 2.5GbE connection showed its use with read speeds of 277MB/sec and write speeds of 234MB/sec. Our real-world test showed promising results, too, with read speeds of 145MB/sec and write speeds of 157MB/s. Switching to an all-flash array, the TS-264 managed faster speeds yet, near identical to those the TS-464 achieved (no surprise, given both devices have two M.2 slots).

If you need more capacity (now or in the future), then the TS-464 is a better buy, but if you're happy with a two-bay device and just want the best performance you can get, then this NAS enclosure is great value.

Do I need special NAS hard disks?

We explain what hard disks you should buy to populate your NAS enclosure

Technically, you can install any hard disk in a NAS. Although it's generally best to use the same type of disk in each slot – the same manufacturer, model and size – if you have spare hard disks lying around then there's no harm in using them.

If buying storage from scratch, you'll have a choice between standard desktop hard disks and models specially designed to be used in a NAS, such as the WD Red hard disks we used for this test. So, what's the difference, and do you really need NAS hard disks?

NAS hard disks have been explicitly designed to work in the confined spaces of a NAS enclosure and are intended to be operated 24 hours per day. As such, they're built to last longer and be more reliable.

For example, a WD Red 2TB Pro hard disk comes with a five-year warranty and can operate at temperatures of up to 65°C, while the WD Red Plus 2TB hard disk has a three-year warranty and can operate at temperatures of up to 65°C. Buy the equivalent WD Blue drive and get a two-year warranty and a drive that can operate at temperatures up to 60°C.

Another comparison is the Mean Time Between Failure (MTBF), which is the average operating time before a disk failure. This doesn't guarantee an operating life, but drives with a higher MTBF typically do last longer. A WD Red Pro has an MTBF of 2,000,000 hours. A WD Blue drive doesn't have a quoted MTBF, but it will be lower.

RIGHT **WD Red drives have been specifically designed for NAS use**

There's some additional technology in NAS drives, too. For example, with the WD Red Pro, there are Rotation Vibration (RV) sensors to counteract disturbances caused by chassis vibration, and shock protection.

If you're buying from scratch, it makes sense to buy hard disks specified for use in a NAS enclosure.

Synology DiskStation DS723+

A fully featured and expandable NAS, which is only let down by the lack of 2.5GbE ports

SCORE ★★★★☆

PRICE £389 (£467 inc VAT) from amazon.co.uk

Synology's top-of-the-range two-bay NAS device, the DS723+, is highly expandable, has lots of power and is easy to set up and install. It includes two Ethernet ports, but these are 1GbE rather than 2.5GbE, which feels outdated on such an expensive product.

But there's so much else here that is great. The DS723+ is a breeze to set up, as it's entirely tool-free. The two SATA hard disk bays on the front have simple keylocks to prevent anyone accidentally pulling a live drive out. Once unlocked, the caddies slide out, and hard disks can be quickly inserted.

If you want SSD caching, two NVMe slots are available underneath. Just remove the screw-free covers and insert the drives into the slots. It's brilliantly simple, whether you want to install the SSDs straight away or upgrade in the future.

This NAS is powered by a dual-core AMD Ryzen R1600 CPU, running at a base clock speed of 2.6GHz with a 3.1GHz Turbo boost. That's powerful enough to handle a wide range of apps, although you may want to upgrade the 2GB of RAM. How fortunate, then, that this NAS has two DDR4 SODIMM sockets, which can handle a total of 32GB of RAM, more than enough for most users' needs.

It's possible to aggregate the two 1GbE ports into one fat pipe, although the number of switches or routers that support this is limited. An upgrade card is available to add 10GbE into the mix, but that adds only one port and requires you to already have a switch or router with a compatible port.

You only get one USB-A port, but an eSATA connector helps compensate, with Synology's five-bay DX517 expansion bay supported. However, if you know you'll want more storage then it's probably better to go with a bigger NAS from the start, such as the Synology DS923+.

We have no complaints about the Synology DSM operating system. It's our favourite choice for NAS devices, starting with the desktop software that makes it easy to find and configure a new NAS.

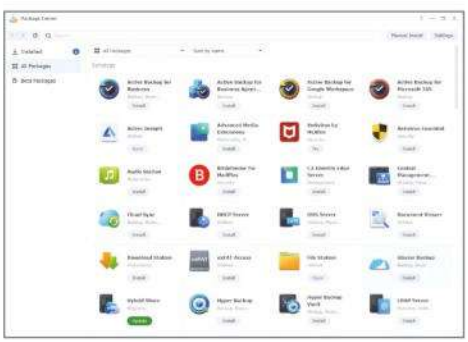
Once the OS is installed, Synology DSM is a joy to use. It walks you through creating a RAID array, helping you find the best choice. Synology Hybrid Raid (SHR) is probably the best bet in most cases, as it supports disks of different sizes and makes it easy to grow the array size in the future. If you want to use SSD caching, DSM makes this easy, too, but you can't use the SSDs in their own storage pool. Once storage is created, the system even takes you through configuring shared folders. It's an absolute dream to use, and we doubt you'll need to turn to the help pages.

One advantage of DSM is the wide range of additional apps you can install, including many made by Synology itself. Synology Drive is great if you want your own Dropbox-style experience, complete with Android, iOS, Windows and Mac clients, while Synology Office gives you a Google Docs-style experience, even if the apps are more basic. There's also Plex for media streaming, Synology's own media server, a photo viewer and Surveillance Station for managing security cameras. In total, there are over 100 apps on offer, from WordPress and phpMyAdmin to Elephant Drive and a DNS server.

ABOVE The DS723+ is a powerful NAS that can be easily expanded

LEFT Sadly, the two ports on the rear are of the 1GbE variety

BELOW Synology's DSM lets you install over 100 extra apps



Despite the 1GbE ports – did we mention them? – performance is strong. With an SSD cache, the Synology DS723+ managed to hit read/write speeds of 113MB/sec in the ATTO 2MB benchmark, which is the limit of the networking tech. Even its 4KB and 16KB results are close to other devices with faster Ethernet ports.

In our real-world copy tests, which use a combination of file sizes, read and write speeds were around the 100MB/sec mark with SSD caching and just below without. That's very good for gigabit Ethernet, but suggests that the NAS could go even faster if it had – well, you know what.

Overall, on a balance of features, performance and quality, there's a lot to like about the Synology DS723+. It's easy to upgrade, has a superb operating system and can handle a huge range of apps, making it more than a dumb file server. Faster network ports would be nice, but at least there's the option of adding 10GbE if needed. But if you need faster performance out of the box, there are better choices.

Asustor Nimbustor 4 Gen2 AS5404T

Powerful and well priced, this is a great choice for everything from streaming to running a small office

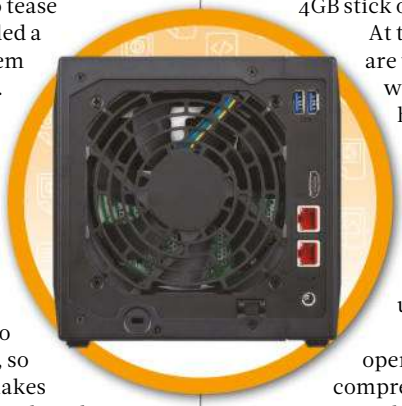
SCORE ★★★★★

PRICE £441 (£529 inc VAT)
from amazon.co.uk

Built for those who demand the best performance, the Asustor Nimbustor 4 Gen2 AS5404T is a four-bay NAS that offers much more than most, with some nice surprises under its standard-looking exterior.

Like other Asustor NAS enclosures, the AS5404T hides its tool-free drive bays behind a magnetically connected fascia. That not only makes the outside look nicer but means that the drives can't be tampered with.

The drive caddies aren't locked and lift out with a simple lever action, making a disconcerting snapping sound as they come free. We struggled to get the caddy clips out and had to use a screwdriver to tease them out; they needed a hard push to put them back into place, too.



The AS5404T takes up to four M.2 SSDs, but to get to the slots, the chassis must be taken apart by removing the screws at the back. The disk caddies also have to be removed, so if you use SSDs, it makes sense to install them when the NAS is new. If you want to upgrade later, make sure you know which order your hard disks came out in, so you can return them correctly.

Fiddly physical installation apart, the combination of four hard disks and four SSDs is powerful. For hard disks, the AS5404T supports all common RAID configurations, including RAID5, 6 and 10. With the M.2 slots, you can use the bays for caching, ultra-fast storage or a combination of the two. For example, a RAID1 pair could be used for caching, leaving you with a secondary RAID1 pair for fast storage. Few other NAS enclosures offer such flexibility in such a small case. Should you need more storage, you can hit a maximum of 16 drive bays by using external expansion units, attached via the three USB-A 3.2 Gen 2 ports.

The quality continues throughout. Internally, the quad-core Intel Celeron N5105 processor is backed up by 4GB of RAM. You can upgrade this to 16GB using the two SODIMM slots, but that means discarding the pre-installed 4GB stick of RAM.

At the rear of the NAS are two 2.5GbE ports, which give you a head start over NAS enclosures that are limited to 1GbE speeds. We find that 2.5GbE is particularly important when using SSDs.

Asustor's ADM operating system is comprehensive and comes with a quick start guide to help you configure your storage automatically. However, you can choose manual configuration if you prefer. After creating a storage pool, the NAS takes a while to synchronise RAID arrays, but it's worth the wait.

One of the most impressive things about ADM is the fully stocked App Center, which is packed with hundreds of apps, covering networking, surveillance, productivity and entertainment. For the latter, 4K transcoding is supported, and there's even an HDMI 2.0b output so the NAS can be connected directly to a TV. That said, it's as easy to install a Plex server and stream content to a smart TV or TV stick. Whether you want to run a small business or move your media collection to a shared server, the Asustor AS5404T has the power and apps to help you.

ABOVE **Asustor's AS5404T is great value and has lots of expansion potential**

PC PRO LABS WINNER

LEFT **The two 2.5GbE ports come in handy when shifting big files**

BELOW **Asustor's operating system helps you keep track of performance**

Performance is exceptional. In the ATTO 4KB file test, which is tough on resources, the AS5404T did brilliantly with hard disks, managing peak read speeds of 40MB/sec and write speeds of 36MB/sec with SSD caching (we recorded slightly slower performance with hard disks alone).

As soon as we moved to the large files test, the AS5404T showed the power of its 2.5GbE ports, achieving read speeds of 281MB/sec and write speeds of 217MB/sec. Real-world performance was impressive, too, with our file copy test showing read speeds of 203MB/sec and write speeds of 195MB/sec, which is just behind the TerraMaster F4-424 Pro.

Moving to an all-flash array, using three SSDs, performance was similar, although the PC Mark 10 Data Drive benchmark increased to 400, and our real-world test delivered blistering write read speeds of 234MB/sec.

In terms of pure raw speed, the TerraMaster F4-424 Pro just wins out, but it's fiddlier to set up and doesn't have the same range of apps. When you consider the brilliant price of this enclosure for its base specifications, and then its upgrade potential, it's a fantastic bit of kit and our Labs Winner.

Qnap TS-464

Powerful, fast and easy to expand, the Qnap TS-464 is a brilliant four-bay device that's well suited to techies

SCORE ★★★★½
PRICE £491 (£589 inc VAT)
from ukstore.qnap.com

Although it has a mid-range price, the Qnap TS-464 has the flexibility and performance of a more expensive device. It's also available in a two-bay version, the TS-264, which we review on p86.

While many NAS devices at this price offer only gigabit Ethernet, this device has two 2.5GbE ports, plus an expansion port if you ever need dual 10GbE ports. Inside, Qnap pairs an Intel Celeron N5095 processor with 8GB of RAM. That leaves a spare SODIMM slot that can take another 8GB stick of DDR4 RAM for a maximum of 16GB – handy if you want to run lots of apps on the NAS.

The four hard drive bays are located at the front of the NAS. They're covered by a panel with a simple slider that locks into place, which is good enough to prevent anyone from accidentally removing a disk while the NAS is in use. It's annoying that the two M.2 NVMe slots aren't accessible without a screwdriver. You must take the case apart to access these slots.

However, the Qnap TS-464 does offer some flexibility in organising storage. The four main hard disk bays support all of the main RAID types, including 5, 6 and 10. Separately, the NVMe SSDs can be provisioned as standalone fast storage or as an SSD cache for a hard disk-based pool.

Qnap's QTS operating system is one of the best, especially for techies, although it's not quite as easy to use as Synology's DSM. We have no complaints about the quality of the App Center, which has a huge range of downloadable options, including media servers, file synchronisation and security camera surveillance.

ABOVE Qnap's TS-464 is a bigger brother to the two-bay TS-264

BELOW An expansion port lets you add to the two 2.5GbE ports

With four hard disks running as RAID5, the TS-464 offers a small performance boost over the two-bay TS-264. Using an SSD cache gave a slight improvement over the raw hard-disk-only tests.

In the ATTO benchmark, the 4KB test completed with a decent read speed of 31MB/sec and a write speed of 37MB/sec, just ahead of its two-bay sibling. The gap increased with 16KB files, where the TS-464 managed write speeds of 112MB/sec, while the 2.5GbE ports showed their worth on the 2MB file test with a 283MB/sec write speed – the fastest in this group. Likewise, our real-world file copy test put the TS-464 towards the top of the table.

Used with SSDs in a RAID1 array, the TS-464 was quicker still, particularly in the 4KB file tests. However, the differences between flash storage and hard disks weren't quite as pronounced as you might think; we'd be tempted to use the NVMe slots for an SSD cache rather than dedicated storage.

At this price, the Qnap TS-464 is a hard combination to beat: it's fast, powerful and very flexible.

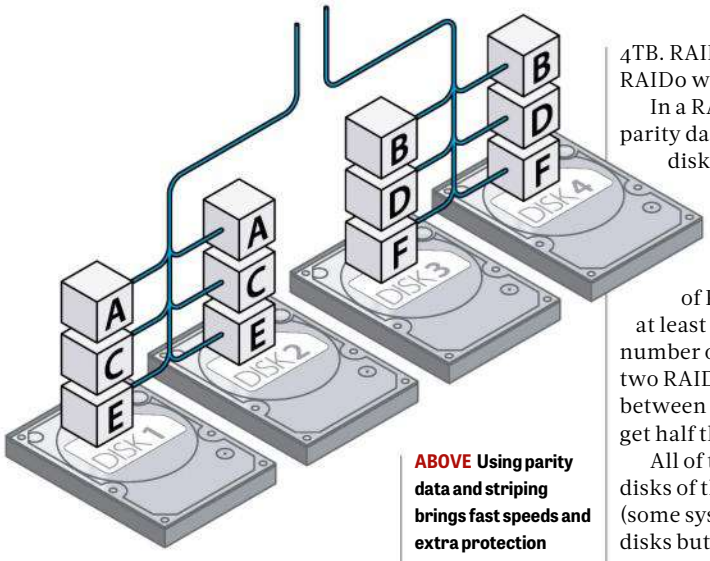
RAID levels explained

Ensure your data is protected by choosing the right RAID level for your needs

A redundant array of inexpensive disks (RAID) lets you use multiple hard disks together in a single pool to boost capacity, data security or both. RAID0 is the most basic and is known as striping. Data is spread evenly across all the disks you have installed, so the total capacity is the total of the hard disks you have installed. Performance is excellent, but if any disk fails you lose all your data.

RAID1 is also called mirroring. It's most often used with two disks; the total storage capacity is the total capacity of all disks divided by two. Data written to one disk is mirrored to another disk, so if one disk fails, you have a complete backup.

Next comes RAID5, which is striping (RAID1) with parity (restoration data), and requires three or more disks. In short, it means that extra data is written across the hard disk pool, so that if any one hard disk fails, your data can be reconstituted. With RAID5, the capacity you get is the total of the disks combined minus one disk's worth. So, if you had three 2TB hard disks, you'd get a total capacity of 4TB. RAID5 gives the speed benefits of RAID0 with extra data protection.



ABOVE Using parity data and striping brings fast speeds and extra protection

In a RAID6 configuration the parity data is doubled, so any two disks can fail without data loss. The total capacity is the number of disks minus two disks' worth.

RAID10 is a combination of RAID1 and RAID0. It requires at least four hard disks and an even number of them. Disks are split into two RAID0 pools and mirrored between them. As you can guess, you get half the capacity of the disk totals.

All of these systems need multiple disks of the same capacity to work (some systems let you mix hard disks but only use the space on the disk equal to the smallest hard disk). Some other systems, such as JBOD (standing for just a bunch of disks) and Synology Hybrid RAID, offer data protection but will work with a range of disk sizes.

Synology DiskStation DS923+

An expandable and flexible four-bay NAS that's great for small businesses despite its gigabit Ethernet ports

SCORE ★★★★☆

PRICE £450 (£540 inc VAT)
from scan.co.uk

The Synology DS923+ has been around for a few years now and remains a high-quality, upgradable four-bay NAS that's a great fit for small businesses.

This model shares a lot with the two-bay DS723+ on p87, but you only pay a little more for the extra two storage bays. And, while both devices have a dual-core 2.6GHz AMD Ryzen 1600 processor, the DS923+ has double the base memory at 4GB.

It's possible to upgrade the RAM to a maximum of 32GB if you use both SODIMM slots and don't mind discarding the existing stick of DDR4 memory. If you're going to run lots of apps, it could well be worth it.

The DS923+ uses Synology's brilliant screw-free design. The four drive bays at the front are all tool-free and unclip to slide out, but can be locked with the provided plastic key. Locking the drive bays will stop anyone accidentally popping a disk out while the NAS is running.

There are two M.2 2280 drive slots for NVMe drives (PCIe Gen 3), both located underneath the NAS. The compartment lids flip open and the drives can be inserted without screws. This makes it easy to add flash storage to the NAS either at the time of installation or later on. One minor restriction is that flash storage can only be used for caching, so you can't create a volume using only solid state storage.

The two gigabit Ethernet ports at the back of the NAS device feel old, when most similarly priced rivals use 2.5GbE. An expansion slot can take a 10GbE card with a single port, but this is quite an expensive upgrade.

There are two USB-A ports for connecting external storage and an eSATA port for Synology's DX517 five-bay expansion chassis. Combined with the four bays in the main device, that gives a total possible capacity of 126TB across nine hard disks.

As with the company's other devices, the DS923+ is managed via the Synology DSM operating system, which remains best in class. After plugging in four 6TB WD Red hard disks, and turning the NAS on, we managed to get DSM installed and running in under ten minutes. DSM then took us through creating a RAID array using Synology Hybrid RAID (SHR), and the system was ready and waiting a few minutes later without the need for any lengthy RAID synchronisation. It's just as easy to turn on caching with the addition of two NVMe drives. Cleverly, DSM takes you through the process and will only allow a read/write cache if you have two NVMe drives configured as RAID1.

As well as being hugely responsive, DSM is exceptionally easy to expand via the Package Center. The range of apps is quite staggering, with Synology having many of its own useful ones including Surveillance Station for security cameras; Synology Office (a Google Drive-style suite of applications); and Synology Drive for a Dropbox-like experience. Best of all, many of Synology's apps also have Android and iOS clients, alongside the traditional Mac and Windows ones.

ABOVE The DS923+ is an excellent choice for small businesses

PC PRO RECOMMENDED

LEFT The two 1GbE ports limit the device's performance

BELOW Synology's DSM operating system is excellent

Media support is superb, too, with Synology's own media server available alongside a photo app and Plex Media Server. You can also run MediaWiki, WordPress, Apache and phpMyAdmin, among other third-party apps.

For backups and synchronisation, there are apps for GoodSync, ElephantDrive and Cloud Sync that work with all the big cloud storage companies. Simply put, there are few other devices that can compete with what Synology has to offer, making the DS923+ a brilliant choice for small businesses that want more than just a big file store.

Testing over 1GbE, it feels as if this still-speedy NAS device could achieve more with a faster network connection. With SSD caching enabled, we managed to get throughputs of around 113MB/sec on the ATTO 2MB test, which is the limit of gigabit Ethernet.

A decent processor and powerful internals meant that the small file performance was stable, with read/write speeds on the ATTO 4KB test of around 32MB/sec. Backing up files in our real-world test, the DS923+ managed read speeds of 105MB/sec and write speeds of 92MB/sec. That's about as fast as you can get without a faster network connection.

There's no denying that the Synology DS923+ is crying out for a network upgrade to 2.5GbE, but even with its pair of 1GbE ports it remains a fast and powerful device that offers a lot to small businesses in particular.

TerraMaster F4-424 Pro

Extremely fast and powerful, this four-bay NAS is great for file storage, but its software lags behind

SCORE ★★★☆☆

PRICE £490 (£588 inc VAT) from amazon.co.uk

Although it looks like the F4-424 we reviewed last year (*see issue 358, p88*), the TerraMaster F4-424 Pro has all-new internals. And a higher price. However, that nets you an eight-core Intel Core i3-N305 CPU (3.8GHz boost speed) and memory slots pre-populated with 32GB of DDR5 RAM, so you're getting a lot for your money. The F4-424 Pro should be ready for anything you can throw at it.

Build quality and usability are mixed. It's great to see four hot-swap hard disk caddies that slide out of the front, but they're not covered and don't have a lock. So, unlike Synology's NAS devices, anyone can pop out a disk whenever they want.

While the hard disks bays are tool-free, the two M.2 2280 NVMe slots (PCIe Gen 3) are only accessible when the case has been unscrewed and removed. That's inconvenient, both in terms of initial installation and for any future maintenance tasks. The dual SODIMM memory slots are also hidden behind this panel, but as the maximum of 32GB of RAM is already installed, you're unlikely to have to touch this.

As with the F4-424, the power button is located at the back, which is inconvenient if the NAS is placed on a shelf; however, given that this device is designed to run permanently, you won't need to get to the back often.

The rear also houses dual 2.5GbE ports, USB-C and USB-A ports and an HDMI output. There's no expansion port to upgrade to 10GbE, though, so look elsewhere if you need this.

The TerraMaster F4-424 Pro runs the company's TOS operating system (a great name that will be remembered fondly by anyone who had an Atari ST). When we first set the OS up, it defaulted to downloading TOS 5, although the newer TOS 6 is available. When we upgraded manually from TOS 5 to TOS 6, we had to recreate our admin username and password, although the storage we'd created remained intact. TOS 6 is a small step up from TOS 5, but functionally it can't match the competition, particularly Synology's DSM. At times, it's clunky and slow.

We set up the four-bay NAS with four 6TB WD Red hard disks, creating a storage pool using the company's proprietary TRAID; this supports different-size disks and easier expansion. After creating these pools, we had to wait for RAID synchronisation, which took the best part of a day, although the system thoughtfully emailed us when it was complete. While synchronisation was going on, we couldn't configure the SSDs as an additional pool and had to wait for that task to finish.

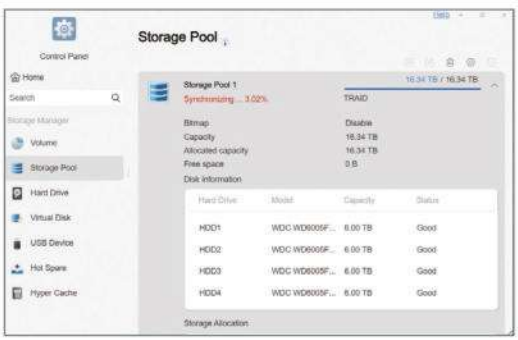
To test SSD caching, we used TerraMaster's Hyper Cache, which was again fiddly to configure: we had to remove the SSD storage pool and then format the SSDs to make the caching available. When setting it up, Hyper Cache would let us create a RAID0 array for caching, though it recommended RAID1.

The range of apps is much more limited here than with the competition, with only 22 official apps supported. There's Plex and a TerraMaster media server; several backup applications; TerraSync for a Dropbox-like experience on Windows and Mac (but not phones); and CloudSync for synchronising with Google Drive, OneDrive, Amazon S3, Dropbox and more. The community provides third-party apps, but they're all unofficial and don't have support. If you need a wider range of apps, you're realistically looking at buying a NAS from a rival.

ABOVE The F4-424 Pro is fast, but is hampered by relatively few apps

LEFT The rear is home to dual 2.5GbE, USB-C and USB-A ports, plus an HDMI output

BELOW TerraMaster's OS is clunky and slow compared to its rivals



While the operating system may not be as good as the competition's, the NAS is exceptionally fast. Kitted out with SSDs, the NAS peaked at 270MB/sec write speeds in the ATTO 2MB test and managed over 200MB/sec in our real-world mixed-file test. Even with hard disks installed (with and without SSD caching), the F4-424 Pro was swift. It's the 4K ATTO test that's particularly interesting, with the NAS light years ahead of the competition with hard disks, hard disks with caching and with SSDs.

Only the PCMark 10 Data Drive benchmark let the side down slightly, but there didn't seem to be any real reason why this would be the case.

The main issue here is that the limited range of apps makes it hard to fully load this NAS and take advantage of its processing power, making the older, cheaper TerraMaster F4-424 a better choice for people who want raw file performance. Otherwise, the Asustor Nimbustor 4 Gen2 AS5404T is a better bet for most buyers.

Synology DiskStation DS1522+

Five bays gives extra storage flexibility to complement the powerful SMB-friendly software and hardware

SCORE ★★★★½

PRICE £558 (£670 inc VAT) from amazon.co.uk

A five-bay NAS, the Synology DiskStation DS1522+ opens up more options and gives more flexibility than a four-bay enclosure. It also has much in common with the other Synology enclosures here, benefitting from a powerful operating system and brilliant apps.

The enclosure has a tool-free design throughout. Hard disk caddies are available from the front of the device, and can be locked into place using the provided plastic key. This simple latching system won't stop a determined thief, but it will stop someone accidentally removing a hard disk while the NAS is running.

Having five bays, rather than four, gives extra flexibility. You can use the extra drive for additional storage space, opting for a single-disk-failure fault tolerance. You can also opt for a system with two-disk redundancy (RAID or via SHR), which means that any two hard disks can fail and your data will remain intact. Alternatively, you can create one three-disk array and one two-disk array, which could be a good way to use up existing hard disks, using two different storage pools for various tasks.

If you need more storage space, there are two eSATA ports at the rear, which give you support for a total of 15 drive bays if you add two DX517 expansion units. That allows you to go from a maximum 80TB of storage with five bays to a staggering 240TB.

With the bays removed, the dual SODIMM memory slots are available. This NAS comes pre-loaded with 8GB of RAM, paired with a dual-core AMD Ryzen R1600 CPU, but you can upgrade to 32GB if you don't mind discarding the pre-installed stick of RAM.

SSD caching is available via the dual M.2 slots. These are accessible without having to take the case apart, so you can install SSDs at the time of installation, or you can hold off and add them at a later date. The only disappointing thing is that you can't use the SSDs as a storage pool; they're a caching option only. And, if you want a read/write cache, you need two SSDs configured as RAID1.

This enclosure has four 1GbE ports, which expands the total network bandwidth available and gives more options if you want to connect the NAS to different subnets. As with the other Synology drives on review, we would have liked these ports to be 2.5GbE, as this kind of connection is increasingly popular and quickly increases the connection speed to the NAS.

LEFT Four 1GbE ports expand the available network bandwidth

If you need a faster connection, you can add a 10GbE port via the upgrade slot at the back. Again, this can be performed without having to take the chassis apart. In terms of assembly and maintenance, Synology is a long way ahead of the competition.

The same can be said of the DSM operating system. It's mature, flexible and supremely powerful. It offers just the right level of handholding to get your system up and running, and the power should you want to take control of how your disks are configured.

ABOVE The five bays in the DS1522+ provide lots of flexibility

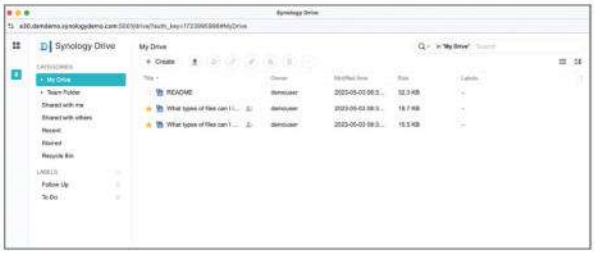
It's also brilliantly supported, both in terms of Synology's applications and third-party add-ons. There's everything from a Dropbox-like client to security camera surveillance software and a fully featured office suite that operates like Google Drive. The range of supporting mobile and desktop software is again unmatched.

Performance from the DS1522+ is generally very good. The tough ATTO 4KB file transfer test resulted in read and write speeds of 39MB/sec with caching enabled, and only slightly below that without. A combination of five populated disk bays, and the higher than average amount of RAM clearly helped. As the file sizes increased, the DS1522+ started to deliver speeds capped by the gigabit Ethernet ports, resulting in 112MB/sec transfer speeds in the ATTO 2MB file test.

We saw write speeds of 96MB/sec and read speeds of 104MB/sec in our real-world tests. Both are quick, but NAS enclosures with 2.5GbE ports do better. PCMark 10 delivered a strong performance, with an overall score of 311, one of the best we've recorded for a system running with hard disks.

Similar to the other Synology products here, the gigabit Ethernet ports are slightly limiting. That said, having four such ports means that bandwidth can be spread out between multiple clients and subnets.

With the base system so good and the expansion options excellent, the Synology DS1522+ remains a top-quality choice for small businesses – particularly those looking to run lots of apps, rather than just having basic networked file storage.



BELOW Synology Drive offers a Dropbox-like experience

Qnap TS-h973AX

A nine-bay NAS with a mix of 3.5in and 2.5in hard disks and SSDs, but cheaper, more flexible options are available

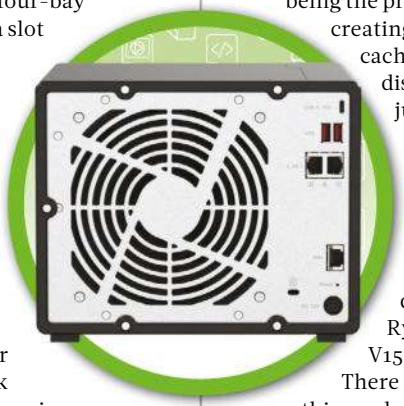
SCORE ★★★☆☆

PRICE £666 (£799 inc VAT)
from ukstore.qnap.com

Qnap's TS-h973AX is a nine-bay NAS, but don't imagine that this enclosure can take nine 3.5in hard disks. Instead, those nine bays can take a mixed collection of storage, all accessible from the front via pull-out drive caddies.

The caddies can be locked into place with a simple key lock. This is enough to stop someone from accidentally pulling out a hard disk while the system is running.

Five 3.5in caddies for traditional hard disks sit at the top of the device. This gives good flexibility, as you can either increase the size of a storage pool compared to a four-bay NAS or use the extra slot with RAID6 for two-disk redundancy.



Underneath sit four 2.5in bays. The bottom two are for SATA disks, either laptop-style hard disks or old-fashioned SATA SSDs. The two upper 2.5in drive bays look similar, but as the warning sticker points out, these are for U.2 NVMe drives rather than the more common M.2 NVMe slot. Don't get the two types of 2.5in caddies mixed up: trying to slot a SATA hard disk into a U.2 slot (or vice versa) risks damaging the connectors on both devices.

The U.2 format was designed for enterprises. Using a 2.5in form factor allows for higher-capacity SSDs, plus these drives are designed to last longer and have higher reliability – both important factors when you're installing storage in a compact device that's designed to run permanently. If you have spare M.2 drives, you can buy an adapter that fits them in a U.2 slot.

It's good to see the U.2 format in a NAS device, but given the enterprise focus, it would have been nice to see four U.2 slots rather than filling out the TS-h973AX with additional SATA ports. Technically, it should be possible, as the rival Asustor Nimbustor 4 Gen2 AS5404T has four M.2 NVMe sockets inside its case.

With two U.2 slots, high-speed flash-only storage options are limited to a storage pool with both disks (RAID1 being the preferred option) or creating a read/write cache for the hard disks. With four slots, just to hammer the point home, you could have had a fast RAID5 array of storage.

It's a powerful NAS thanks to a quad-core AMD Ryzen Embedded V1500B processor. There are two versions of this product, one with 8GB of RAM (as reviewed) and one with 32GB. You can use the two SODIMM DDR4 slots to upgrade to a maximum of 64GB, which is worthwhile if you're thinking about running a lot of apps .

Three network ports sit at the rear: two 2.5GbE plus one 10GbE, making this the only device on test to come with one. You'll also find a USB-C 3.2 Gen 2 port and a pair of USB-A 3.2 Gen 2 ports (10Gbits/sec), which can be used for adding expansion enclosures.

ABOVE The nine bays in Qnap's TS-h973AX can take a mixture of storage solutions

LEFT Network ports comprise one 10GbE and two 2.5GbE ports

BELOW The QTS operating system is generally easy to use

Qnap's QTS operating system is generally easy to use, but as noted elsewhere it can feel techie: setting up storage, it's nice to have the choice between thin and thick provisioning, but there's no simpler automated setup.

With the App Center, you can download and add many extra features, ranging from file synchronisation and backup to media servers and a surveillance centre for security cameras. Compared to Synology, the only obvious omissions are a mail server and an office suite.

Performance with hard disks is generally very good, although we didn't have U.2 drives to test this model with, so only used a five-disk hard disk array. It faced down the tough ATTO 4KB test with 31MB/sec read and write speeds, although we'd expect to see an improvement of a couple of MB/sec with SSD caching.

With larger files, the power of the NAS and its speedy Ethernet ports start to shine. Using a 2.5GbE client, we saw the ATTO 2MB file test return read speeds of 278MB/sec and write speeds of 281MB/sec, putting this NAS close to the top of the table compared to other NAS devices using hard disks or all-flash storage. SSD caching, again, should improve results.

There's a lot to like about the Qnap TS-h973AX. It's fast and powerful, has very fast Ethernet ports and a brilliant operating system. However, four U.2 bays would have added far more flexibility. As it stands, unless you need the benefits of U.2, the four-bay Qnap TS-464 with its two NVMe drive slots is better value, while the Asustor Nimbustor 4 Gen2 AS5404T has more flexibility with four hard disk bays and four NVMe slots.

How we test

As this Labs focuses on home and small office NAS devices, it was important to test them with a realistic setup. We used a Windows 11 desktop PC with an Intel Core i7-12700K processor and 32GB of RAM. This PC has an integrated 2.5GbE port.

For networking tests, we connected the PC and the NAS device to an Eero 7 Max satellite, which has two native 2.5GbE ports and two 10GbE ports. We feel that 10GbE, in the environments we're testing for, is more for backhaul, which is why we stuck with 2.5GbE for testing.

Each NAS was fitted with its maximum number of disks, and Western Digital kindly loaned us 6TB WD Red Pro hard disks for this purpose. We configured the RAID array for the maximum data protection and speed for each device.

For two-bay devices, this meant using RAID1. On four-bay devices, we used RAID5 (or SHR with one redundant disk); with five-bay devices, we used a two-disk-redundancy configuration

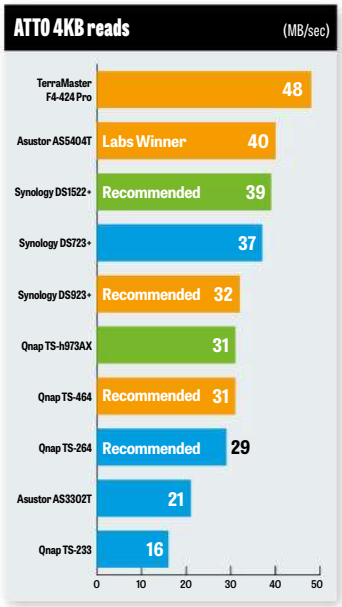
Where a NAS had NVMe slots, we added two WD Red 500GB SSDs and repeated our tests with them configured as a read-write cache in a RAID1 array. Where supported, we also configured and tested these as a standalone flash volume, opting for three SSDs in a RAID5 array where more than two slots were available.

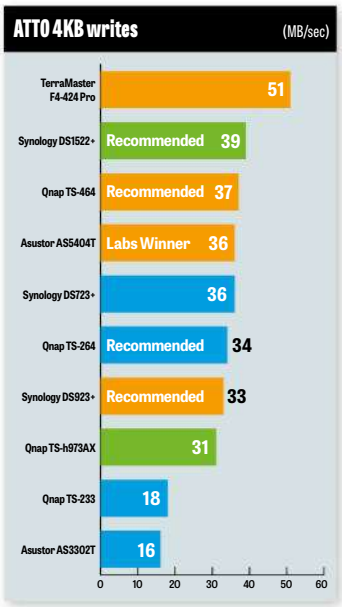
All disks were formatted with Btrfs, and we waited for synchronisation tasks to complete before testing.

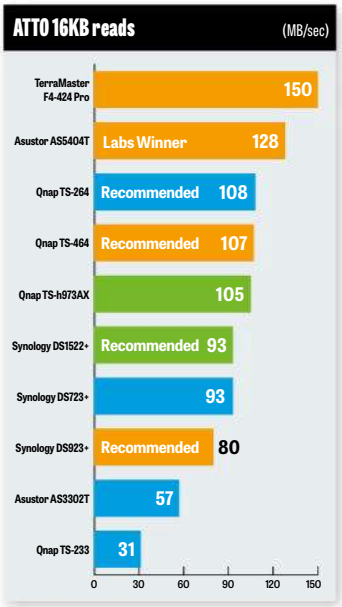
We tested transfer speeds with ATTO Disk Benchmark, looking particularly at 4KB, 16KB and 2MB file operations. We also ran the PCMark 10 Data Drive benchmark (supplied here purely for information as we didn't make speed judgements using this).

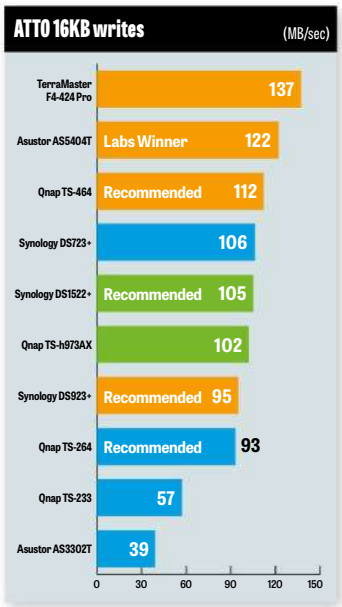
Finally, we tested real-world performance with a 19.3GB folder in Windows 11. This 4,848-file test contained a 9.68GB ISO file, nearly 9GB of photos and almost 1,000 small files averaging 700KB each.

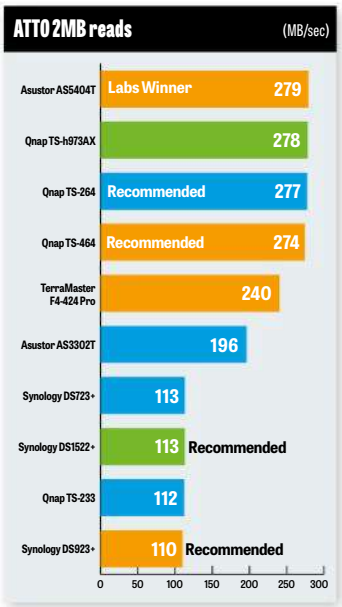
Hard disk tests

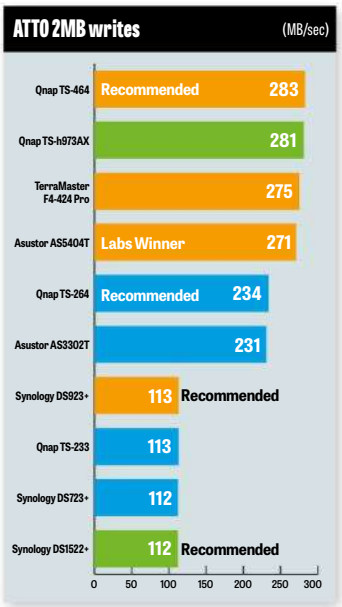


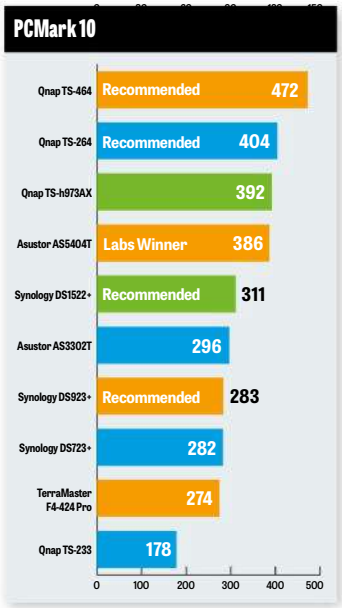

ATTO 4KB writes (MB/sec)
TerraMaster F4-424 Pro 51
Synology DS1522+ Recommended 39
Qnap TS-464 Recommended 37
Asustor AS5404T Labs Winner 36
Synology DS723+ 36
Qnap TS-264 Recommended 34
Synology DS923+ Recommended 33
Qnap TS-h973AX 31
Qnap TS-233 18
Asustor AS3302T 16
0 10 20 30 40 50 60

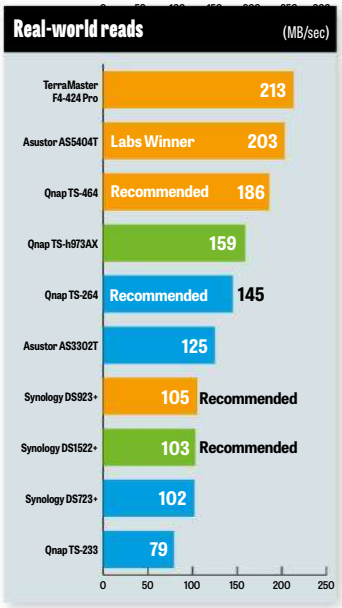


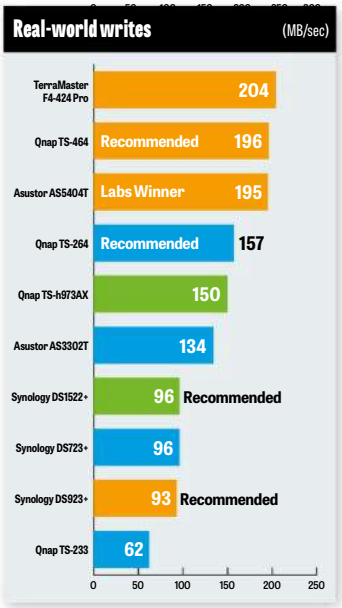



ATTO 2MB reads (MB/sec)
Asustor AS5404T Labs Winner 279
Qnap TS-h973AX 278
Qnap TS-264 Recommended 277
Qnap TS-464 Recommended 274
TerraMaster F4-424 Pro 240
Asustor AS3302T 196
Synology DS723+ 113
Synology DS1522+ 113 Recommended
Qnap TS-233 112
Synology DS923+ 110 Recommended
0 50 100 150 200 250 300

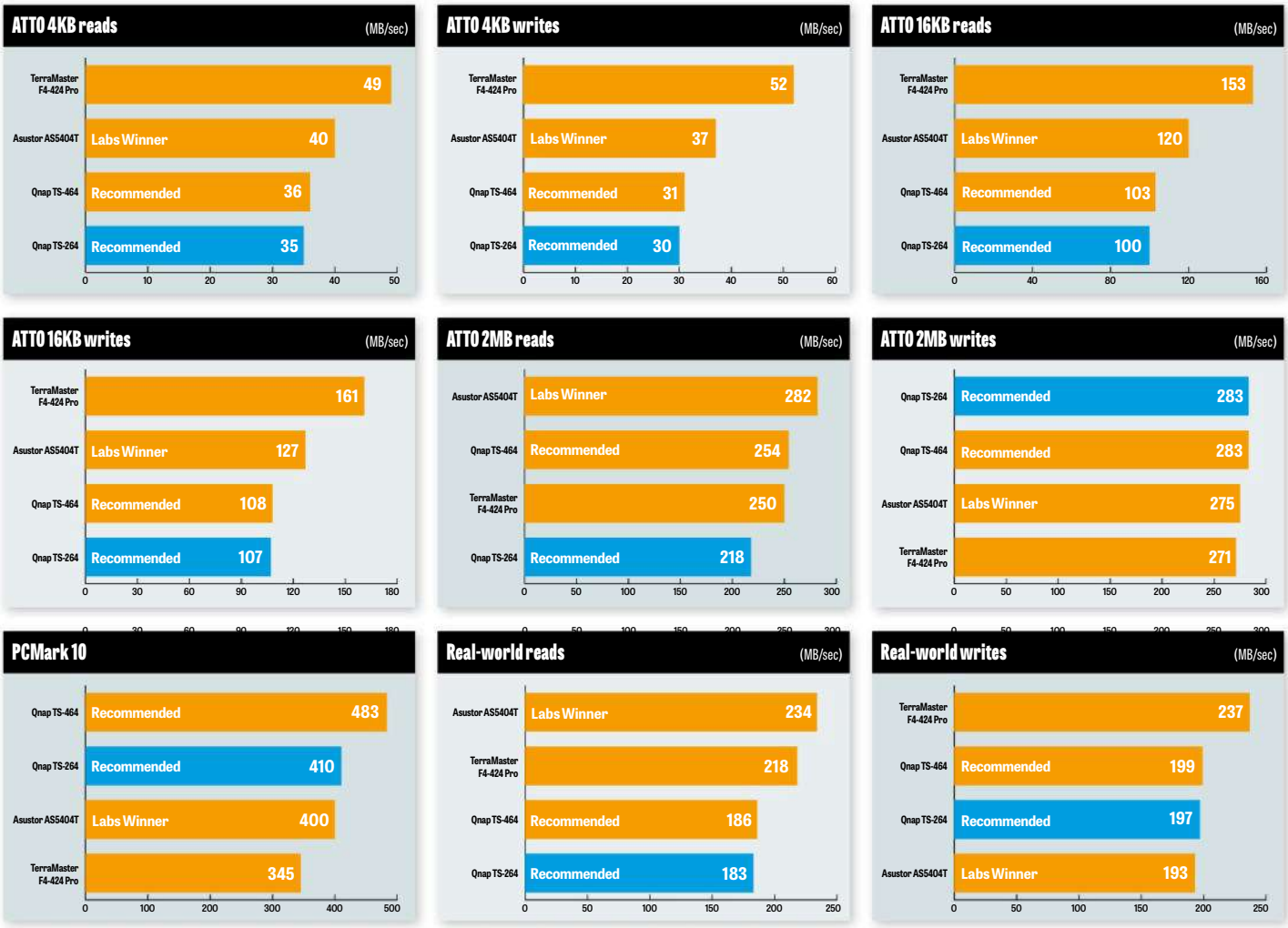

ATTO 2MB writes (MB/sec)
Qnap TS-464 Recommended 283
Qnap TS-h973AX 281
TerraMaster F4-424 Pro 275
Asustor AS5404T Labs Winner 271
Qnap TS-264 Recommended 234
Asustor AS3302T 231
Synology DS923+ 113 Recommended
Qnap TS-233 113
Synology DS723+ 112
Synology DS1522+ 112 Recommended
0 50 100 150 200 250 300







SSD storage tests


ATTO 4KB reads (MB/sec)
TerraMaster F4-424 Pro 49
Asustor AS5404T Labs Winner 40
Qnap TS-464 Recommended 36
Qnap TS-264 Recommended 35
0 10 20 30 40 50
ATTO 4KB writes (MB/sec)
TerraMaster F4-424 Pro 52
Asustor AS5404T Labs Winner 37
Qnap TS-464 Recommended 31
Qnap TS-264 Recommended 30
0 10 20 30 40 50 60
ATTO 16KB reads (MB/sec)
TerraMaster F4-424 Pro 153
Asustor AS5404T Labs Winner 120
Qnap TS-464 Recommended 103
Qnap TS-264 Recommended 100
0 40 80 120 160
ATTO 16KB writes (MB/sec)
TerraMaster F4-424 Pro 161
Asustor AS5404T Labs Winner 127
Qnap TS-464 Recommended 108
Qnap TS-264 Recommended 107
0 30 60 90 120 150 180
ATTO 2MB reads (MB/sec)
Asustor AS5404T Labs Winner 282
Qnap TS-464 Recommended 254
TerraMaster F4-424 Pro 250
Qnap TS-264 Recommended 218
0 50 100 150 200 250 300
ATTO 2MB writes (MB/sec)
Qnap TS-264 Recommended 283
Qnap TS-464 Recommended 283
Asustor AS5404T Labs Winner 275
TerraMaster F4-424 Pro 271
0 50 100 150 200 250 300
PCMark 10
Qnap TS-464 Recommended 483
Qnap TS-264 Recommended 410
Asustor AS5404T Labs Winner 400
TerraMaster F4-424 Pro 345
0 100 200 300 400 500
Real-world reads (MB/sec)
Asustor AS5404T Labs Winner 234
TerraMaster F4-424 Pro 218
Qnap TS-464 Recommended 186
Qnap TS-264 Recommended 183
0 50 100 150 200 250
Real-world writes (MB/sec)
TerraMaster F4-424 Pro 237
Qnap TS-464 Recommended 199
Qnap TS-264 Recommended 197
Asustor AS5404T Labs Winner 193
0 50 100 150 200 250

View from the Labs

Features and flexibility are important, but you need the network speed to keep up

When buying a NAS device, it's vital to think about flexibility. Starting with the basics, that means buying the right number of bays for your needs. However, it's also about your ability to use SSD storage in the way that you want. It's becoming increasingly common to see NAS enclosures that let you use SSDs in a storage pool, for fast, quiet storage, not caching alone. That becomes even more important if you can use four NVMe drives instead of two.

Layered on top that is the NAS enclosure's operating system and range of apps. Sure, a NAS must provide network-connected storage, but modern devices are fully fledged servers that can provide everything from media streaming and security camera surveillance to Dropbox-style file synchronisation.

David Ludlow is a current fan of NAS drives and a former editor of *Computer Shopper*

Then we come to networking, and in particular whether you need 2.5GbE. You don't need new cables – it easily runs on existing Cat5e cables – while ever more routers, switches and mesh systems have the ports as standard. NAS devices that have two or more gigabit Ethernet ports might offer a similar total bandwidth, but you need more cables and each single client is limited to the slower speed.

What's more, while some NAS devices offer port aggregation, where you can join two 1GbE ports into one fat pipe, the technology isn't well supported on connecting clients. You can argue that 2.5GbE isn't yet common on clients either, but it's easy and cheap to buy a USB adapter.

How much does it matter? With smaller, individual files, you probably won't notice the benefit of 2.5GbE, but the technology still increases the total bandwidth available to clients, and SSD caching helps keep that full bandwidth available for multiple users.

Start dealing with larger project files, however, and 2.5GbE NAS devices can deliver speeds up to 283MB/sec, compared to the 113MB/sec maximum that 1GbE offers. That's a huge difference, making NAS devices with faster Ethernet ports far more attractive than those without. And for those devices, an upgrade to faster Ethernet via an expansion card or USB, if supported, is one of the first things you should consider.

Buyer's guide

VoIP buyer's guide 2025

Businesses stuck on PSTN may have a year-long extension, but with competition this fierce it's time to pull the cord for good, says Dave Mitchell

Businesses that still haven't made the switch to voice over internet protocol (VoIP) have just been given a lifeline. Openreach had originally planned to close down the entire public switched telephone network (PSTN) and integrated services digital network (ISDN) by December 2025 but has now extended this final switch-off date to the end of January 2027.

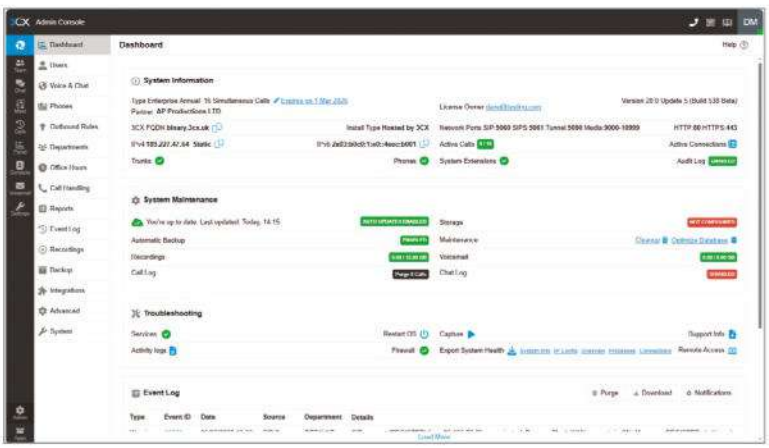
The main reasons for this extension are to provide support for the near 2 million people in the UK that rely on in-home telecare services such as personal alarms, to allow manufacturers to implement digital life line alarms and to give residents in rural areas more time to switch. This doesn't mean businesses can ignore the great switch-off, however, as it will happen – and when it does, all legacy analogue systems in use will stop working for good.

There are a number of companies that are still completely unaware of this. A recent study conducted by UK service provider Zen (**tinyurl.com/369zenswitch**) found that 9% of respondents from larger businesses were in this category, rising to 12% for small businesses. Furthermore, Openreach has changed its terms for wholesale line rental (WLR) services and can issue a 90-day notice to cease a PSTN/ISDN line.

Businesses yet to migrate to VoIP should use this extra time wisely to choose the best provider and ensure all problems are ironed out well in advance. The good news is that VoIP is a mature, flexible and affordable technology, and this month we've tested four business solutions to help you make a timely transition to digital communications.

No time to lose

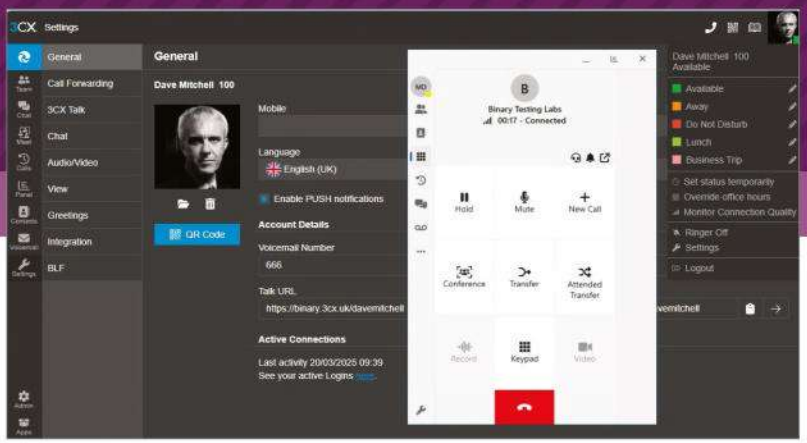
When planning the move to VoIP don't leave anything to the last minute as there are many factors that must be considered. First, you'll need a fibre installation; if you already have fibre to the premises, this is one hurdle you've overcome.



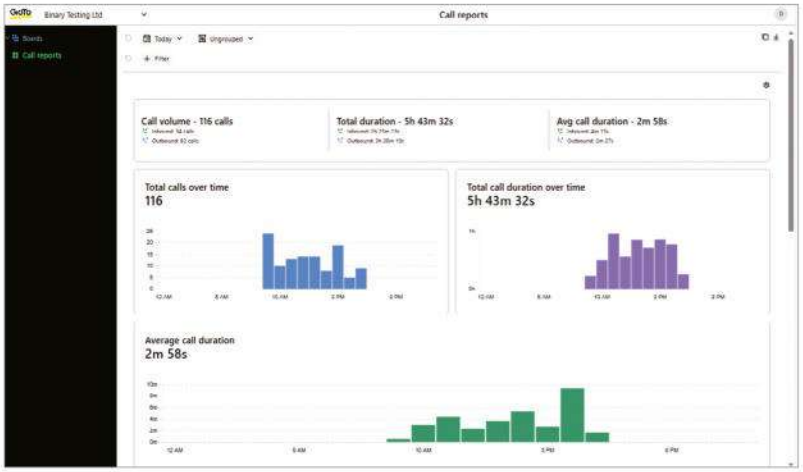
BELOW 3CX's Phone System 20 can be run on-premises or in the cloud

Don't assume this will be a swift and simple process. It's hopefully an extreme example, but we have personal experience of a company that placed an order for fibre to the premises and, due to a staggering number of cock-ups in the ordering system, had to wait nearly nine months before it was finally installed.

Business operations will rely on your VoIP system, so consider a secondary internet connection for use as backup should the main link fail. We've reviewed plenty of



LEFT **The 3CX Phone System client app is fully integrated into the admin console**



LEFT **The GoTo Connect web portal presents detailed call reports to users**

affordable security appliances that combine fixed-line and 5G failover services, and one vendor in this guide offers a 4G/5G router to provide emergency backup services.

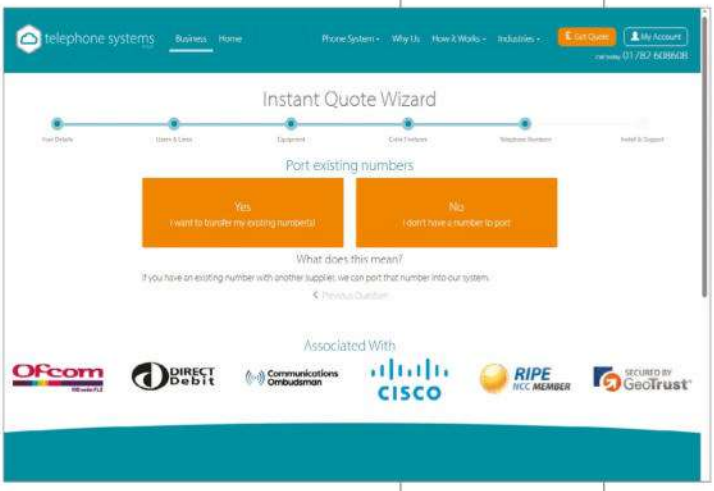
Next, you need to decide whether to host your own VoIP system or use a managed service provider. Both options have their pros and cons, and there are a number of essential details you need to be aware of.

On-site VoIP

A self-managed VoIP system will cost a lot less over the long term and gives you full control over voice services and access security. It's far from plug-and-play, though: you'll need some technical expertise to deploy it and, if you're running it on-site, you should use a good-quality host system as this can be a single point of failure.

Hosting in the cloud is a great alternative as it negates the need for on-premises hardware. The self-managed VoIP solution we review here gives you loads of options as you can run it on-premises, in your private cloud or let the vendor host it in their own cloud for you.

Whichever path you take, you'll need a session initiation protocol (SIP) trunk to route VoIP calls over the public network. Prices are usually based on the number of call lines, or channels, you require; a good starting point is to purchase one SIP channel for every three users.



ABOVE **An online quote service from TelephoneSystems. Cloud lets you see all costs before signing up**

To test the self-managed VoIP system, we use the SIP trunk services from T4Com Ltd (**t4com.co.uk**). Monthly costs are very affordable, and T4Com offers full redundancy as it owns and operates its own infrastructure, which is mirrored across two data centres.

VoIP has left the building

SMBs that don't feel confident enough to run their own VoIP system should consider managed services. The best providers will do the heavy lifting for you by assigning an account agent to handle the entire deployment process, and you won't need to worry about SIP trunks as these are included.

There's an ever increasing number of VoIP providers on the market, so it's important to pick the one that best suits your budget and requirements. UK businesses have plenty of local providers to choose from, and customer support is likely to be more responsive.

Many offer call plans based on the number of monthly inbound and outbound call minutes per user, so evaluate your current phone usage to make sure you get the right one. Demand is certain to change over time so confirm that you can easily upgrade or downgrade a plan to keep in step with your requirements.

"A self-managed VoIP system will cost a lot less over the long term and gives you full control over voice services and access security"

The Openreach switch-off extension gives businesses more time to evaluate different solutions to ensure they have the features they need. Some even offer unified communications (UC) services that amalgamate voice, messaging, meetings, contact centres and videoconferencing into a single platform.

Soft power

If your staff require physical handsets, all VoIP solutions support a wide range of IP desk phones and can provision them for you. Only buy used ones from reputable dealers, ensure they're fully supported by the manufacturer with firmware updates, and confirm that they have been de-provisioned first, otherwise they may be unusable.

Many businesses may not need physical handsets as all good VoIP providers include softphone apps in the price. Available for Windows, macOS, iOS and Android, these apps are becoming ever more sophisticated and can be used with cheap, lightweight headsets.

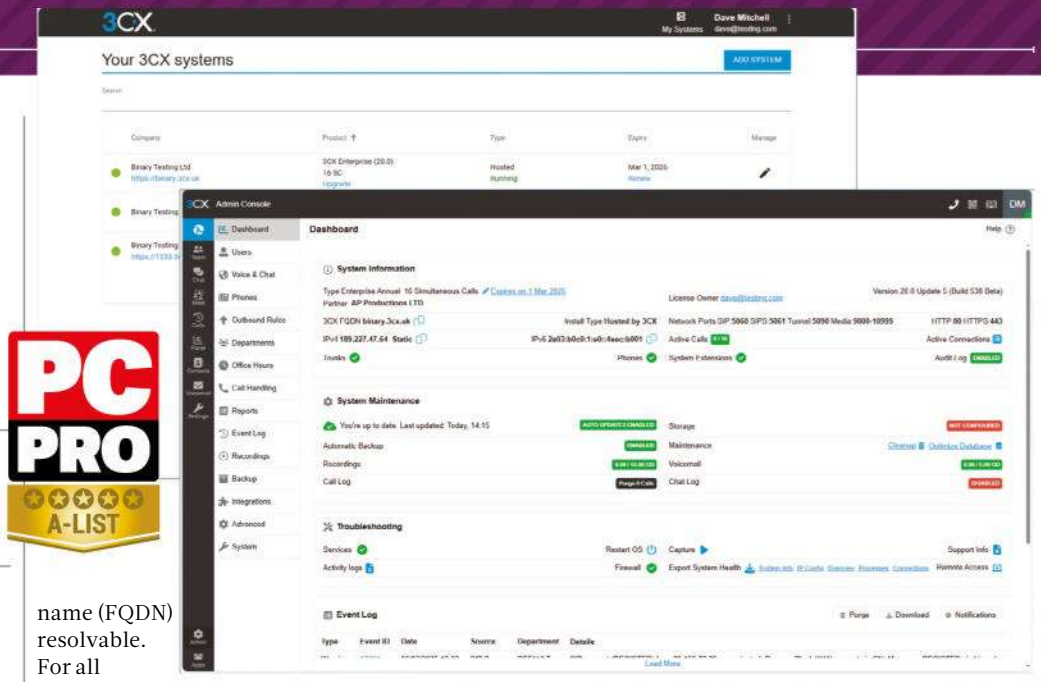
Businesses that think VoIP is optional should realise that resistance is futile as they have 18 months to ditch their PSTN systems. There's nothing to worry about – the solutions we review here are all incredibly affordable, easy to install and rich in call-handling features. Read on to see which one best suits your business.

3CX Phone System 20 Update 5

The IP PBX host with the most offers classy features and flexible deployment options at a tempting price

SCORE ★★★★★

PRICE Enterprise, 8SC, £385 exc VAT per year from 3cx.com



3CX's Phone System is probably the best self-hosted IP PBX on the planet, and its new pricing structure makes it even more affordable. Instead of per-user pricing you pay one annual licence fee, and the various plans have been simplified, making it even easier to choose the right one.

Small businesses with up to ten users will love the 3CX Free edition. It's hosted in the cloud for you and offers a solid set of PBX, call centre and videoconferencing features. The Professional and Enterprise editions support unlimited extensions, and licences are based purely on the number of simultaneous calls (SCs).

We reviewed Phone System Enterprise, which starts at £385 for an 8SC licence and enables everything 3CX has to offer. You can run it on-premises or in your own private cloud, but we opted to have 3CX cloud host it for us. For an 8SC licence, this adds an extra £270 to the yearly bill.

Cloud hosting offers many advantages. Unlike the on-premises versions, you don't need to create firewall forwarding rules for SIP and RTP port ranges or worry about making the system's fully qualified domain name (FQDN) resolvable. For all versions, you'll need a paid-for SIP trunk to enable VoIP calls; we use the excellent UK-based T4com Ltd service provider.

Phone System 20's redesigned admin console is fully integrated into the client app, so you don't need separate consoles to use and manage the system. All admin features are accessible from the left menu, which provides direct access to calls, chats and voicemail, with icons to the top right for quick links to a dial pad and availability status settings.

The dashboard presents a full summary of the Phone System status, configuration and event logs so you can see at a glance if all is well. Adding new users is simple: each one receives an email with their account details along with a voicemail PIN and links for 3CX Talk, virtual meetings, mobile apps and the Windows softphone.

3CX has a sharp focus on security as user accounts can be protected with two-factor authentication. Its systems are hardened against cyberattacks, and a zero trust model provides stricter access control policies.

ABOVE The user interface is packed with features

> **"3CX offers all the call-handling services any business could need, including ring groups, call queues, call forwarding and recording"**

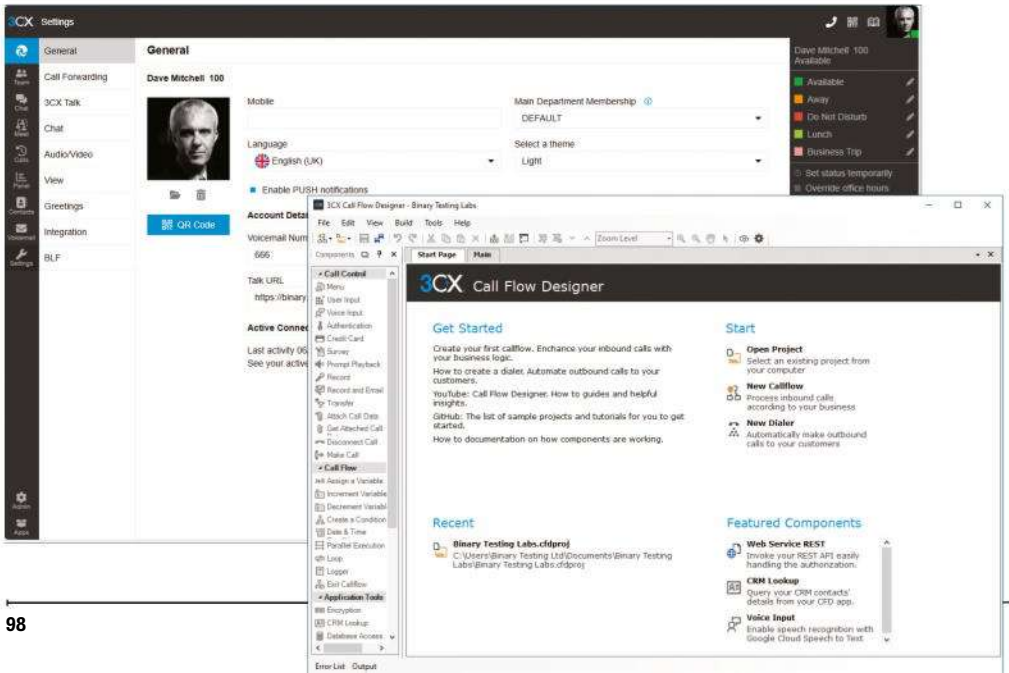
Most users will be happy with the softphones but 3CX supports a huge range of hardware IP phones. To use our non-router Yealink desk phones, we installed 3CX's small-footprint SBC (session border controller) utility on a Windows 10 host and after linking it to our cloud account, could easily deploy them to users by entering their provisioning URL.

3CX offers all the call-handling services any business could possibly need, including ring groups, call queues, a digital receptionist, call forwarding and recording, as well as integrations with Microsoft 365, Teams, Google Workspace and a host of CRM apps. Phone System Enterprise takes everything from the Professional edition and adds high-level features including system standby and failover services plus 3CX AI-powered call transcriptions and analytics, while skill-based routing passes calls to agents based on their skill group membership.

The separate Windows utility Call Flow Designer allows you to create and upload multiple call-routing and dial plans based on criteria such as caller inputs and rules. Plans are easily created using drag and drop, with this latest version adding date and time conditions for office hours, holidays and custom periods.

Businesses that want to manage their own VoIP services will find 3CX Phone System 20 the perfect partner. Deployment options are extensive, call handling features are excellent and, although you'll need to source a SIP trunk, it's incredibly affordable.

BELOW All admin features are neatly integrated into one web console



REQUIREMENTS

On premises: Windows 10 Pro/Enterprise, Windows Server 2016 upwards, Debian Linux 12, Raspbian (SBC only)

GoTo Connect Phone System

An easily deployed cloud-hosted solution with a feature set larger businesses will find very appealing

SCORE ★★★★☆

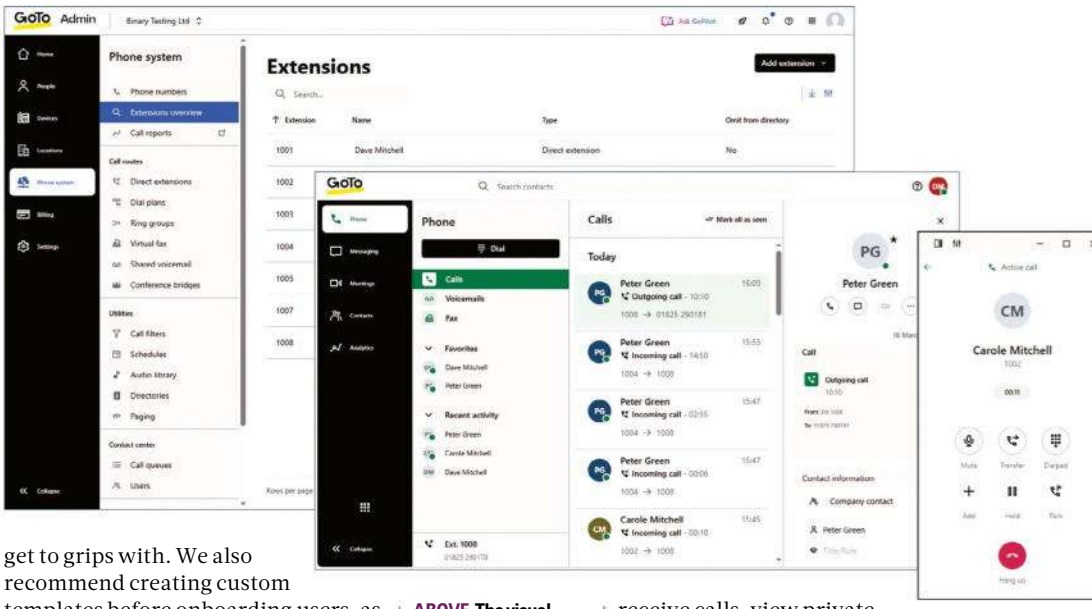
PRICE From £21 exc VAT per user per month from goto.com

It's easy to see why GoTo is a popular choice for cloud-hosted VoIP services as it delivers an incredible range of unified communications features. The Connect Phone System on review offers a wealth of call-handling services, teams them up with messaging, meetings, chat and videoconferencing, adds new AI-powered calls and presents them all in one administration portal.

GoTo has simplified its plans, with Phone System offering all the VoIP services most businesses will likely need. Price transparency is lacking so you'll need to request a quote, but we were advised that prices start at £21 per user per month for up to ten seats, dropping to £16 for larger volumes.

All your GoTo products are accessed from the account admin portal. This offers options to view licences, phone number orders plus app integrations and create detailed custom reports. The system health page is a smart feature that presents graphs of audio quality, call volumes, audio delays, packet loss and the volume of SMS delivery.

It's worth familiarising yourself with the Phone System interface before deployment as there's a lot to get to grips with. We also recommend creating custom templates before onboarding users, as these contain settings that determine all the phone and meeting features they're permitted to access and the destinations they can call.



ABOVE **The visual editor makes light work of call routing**

When creating users, you provide their names and email addresses, apply a template, dish out phone numbers, assign extensions, choose member, admin or super admin roles and optionally apply multi-factor authentication for tighter access security. When users create their account they're provided with a personal web portal; the Windows and macOS desktop apps must be downloaded separately, although they may not be needed as their interfaces are identical to the web portal.

The focus is clearly on softphones but you can add physical phones, with GoTo supporting heaps of models for all key vendors. From the portal's Devices page, you choose the model, provide its MAC address, assign it to a user and leave GoTo to provision it.

The web and desktop apps provide a side menu for accessing all features, allowing users to easily make and receive calls, view private, company and shared contacts and have direct or team chats. They can add reference notes to calls, load an analytics page for a detailed breakdown of all their calls over custom time periods and call up the smart new AI feature to view summaries of calls and voicemail.

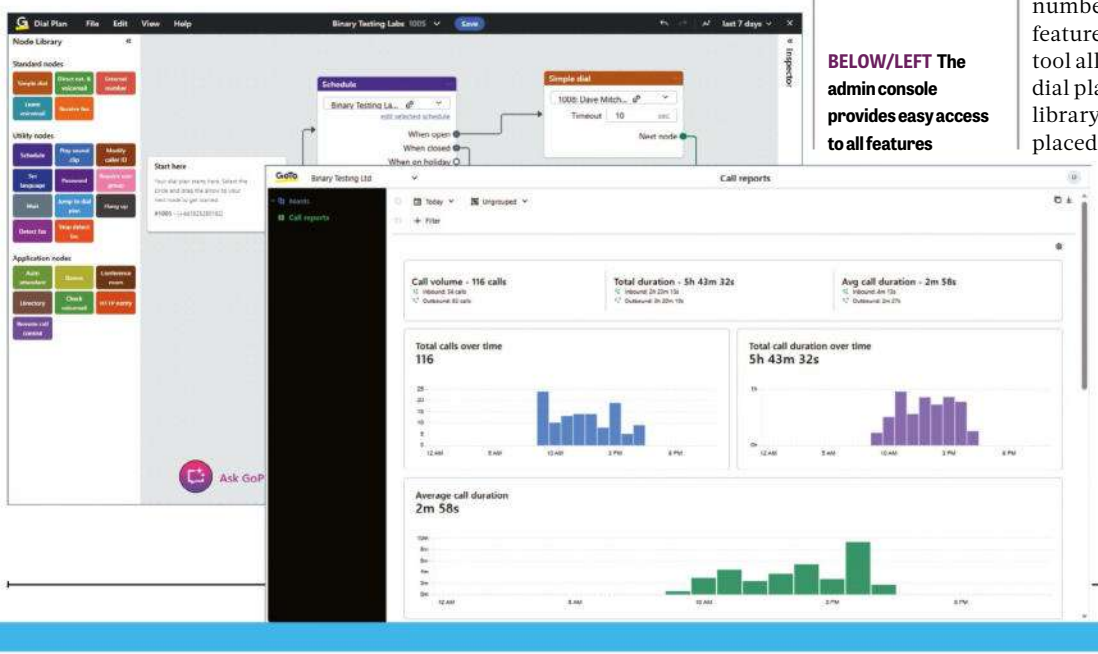
Creating scheduled and instant VC meetings is a breeze, as users email invitations, create personal meeting rooms and add co-organisers. Breakout rooms can be used to split participants into smaller groups for side discussions, and end-to-end encryption is applied to all communications.

"Admins will be bowled over by the number of call-handling and routing features to hand, and the editor tool allows them to build extensive dial plans"

The price includes call recording to your account system storage, which retains them for 13 months. You can decide what types of calls to record, and for longer retention periods you can direct them to your own Amazon S3 cloud buckets.

Admins will be bowled over by the number of call-handling and routing features to hand, and the portal's editor tool allows them to build extensive dial plans. Nodes are dragged from the library into the main window and placed in sequences that determine how incoming calls will be handled, and the Insights feature shows a real-time view of the plan's performance.

GoTo Connect Phone System may be over-specified for small businesses but it will appeal hugely to larger firms that want a complete cloud-hosted communications solution. It's easy to manage, the new AI-powered features are very sophisticated, and it delivers outstanding call-handling features.



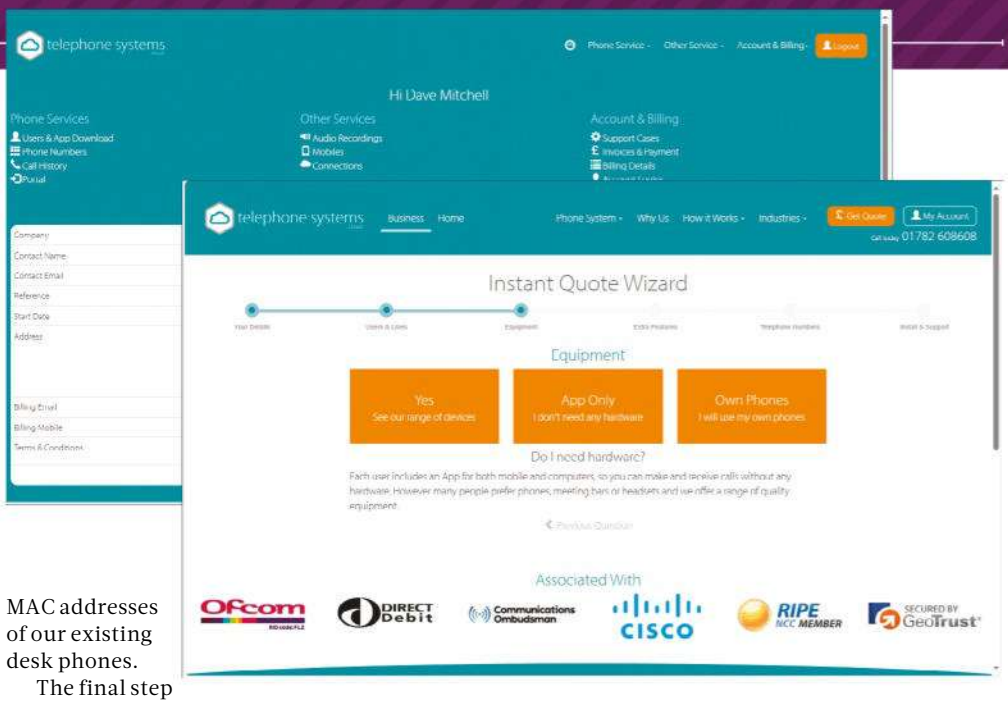
BELOW/LEFT **The admin console provides easy access to all features**

TelephoneSystems.Cloud

Clear pricing and a smart online quote system make this VoIP-to-go service ideal for SMBs

SCORE ★★★★½

PRICE From £11 exc VAT per user per month from telephonesystems.cloud



Businesses worried about hidden costs and lengthy VoIP service contracts will find a lot to like about TelephoneSystems.Cloud. This UK-based provider charges a flat £11 per user per month and doesn't tie you in with fixed-term contracts so you can cancel at any time.

You don't have to negotiate with a sales representative, either, as the company offers a slick online quote system. This guides you through the entire ordering process and presents a clear breakdown of charges before asking you to commit.

To test the quote process, we requested five users, chose our own internet provider and opted for softphones and our existing desk phones. If your desk phones are the same make and model, you pay only a single setup fee of £25 for all of them.

We skipped the optional Webex Teams+ and Presenter, asked for new UK phone numbers, selected the automated installation service and were presented with an itemised bill. After providing our banking details, we were directed to another web page requesting our preferred area code, details of the services required such as call groups and queues, and the MAC addresses of our existing desk phones.

The final step was to create our users, provide passwords and add extension numbers for them. We then received an email and SMS telling us the account was being configured and it was ready to go in two hours.

You get two portals: one with details of your account, facilities for onboarding users and a login link for the main admin portal. Users are set up by sending them an email from the account dashboard, which includes links to mobile apps and the Webex Windows and macOS clients.

This is the standard Webex client so users can easily make and receive calls, create a personal contacts list, schedule and start meetings, view their voicemail and use the integral videoconferencing services. The price includes free calls to UK 01/02/03 numbers and mobiles, with a generous monthly fair use limit of 5,000 minutes per user.

A redesign to the admin portal makes it even easier to use, and we were bowled over by the range of call-handling features. Along with call centre, call parking plus groups for ringback, hunt and pickup, you can build extensive interactive voice response (IVR) services directly from the portal using its intuitive menus to assign key presses and actions to determine how calls are handled and transferred during business hours, after hours and holidays.

ABOVE The portal provides a wealth of features and detailed usage statistics

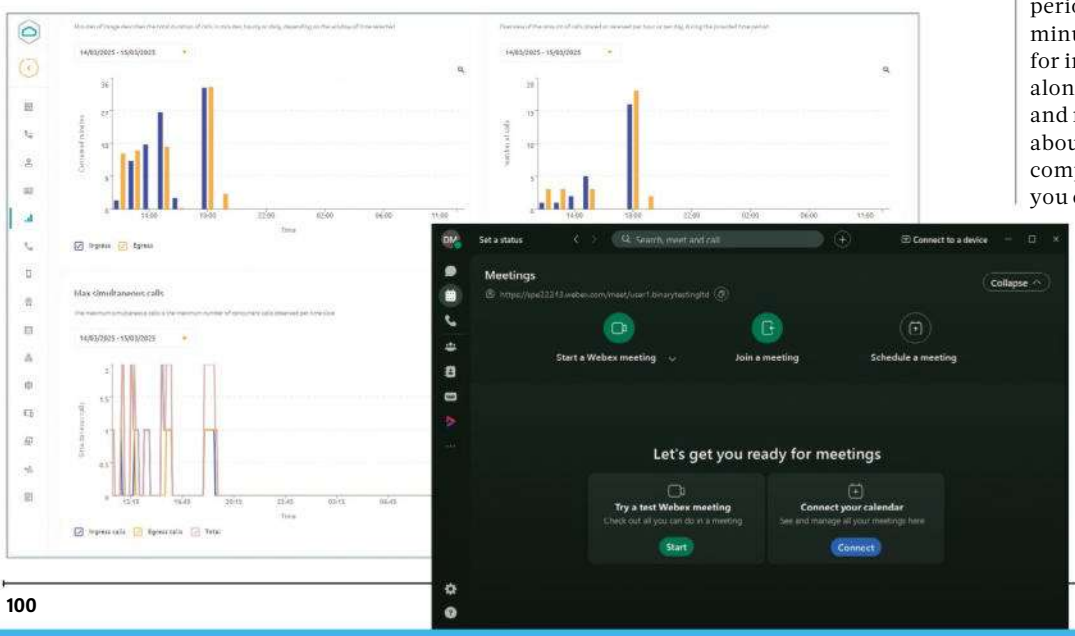
PC PRO RECOMMENDED

"Total price transparency makes TelephoneSystems.Cloud ideal for businesses that don't want any unpleasant billing surprises"

Outgoing call plans control the destinations calls can be made to. You can limit access by assigning authorisation codes, and group contacts can be synced to Webex so they appear in the apps. For voice prompts such as welcome messages, you can upload your own audio files into an online library or record them directly from the portal. TelephoneSystems.Cloud also offers an AI text-to-speech service, which costs £10 per recording. It's worth trying due to the professionalism of the results.

The portal provides a wealth of call statistics, with graphs showing total traffic volumes over selected periods broken down into usage minutes and calls with more charts for inbound and outbound traffic along with insights into call duration and ring times. If you're worried about internet redundancy, the company offers a 4G/5G router that you can rent or buy and, in an emergency, will get one to you within 24 hours.

Total price transparency makes TelephoneSystems.Cloud ideal for businesses that don't want any unpleasant billing surprises. The online quote service is impressively smooth, the service is very affordable, and it offers an impressive range of professional call-handling features.



BELOW The quote process is smooth and the account dashboard simplifies management

Voip Unlimited Voxone

Feature-rich and affordable, Voxone offers easily deployed and reliable cloud-hosted UC services

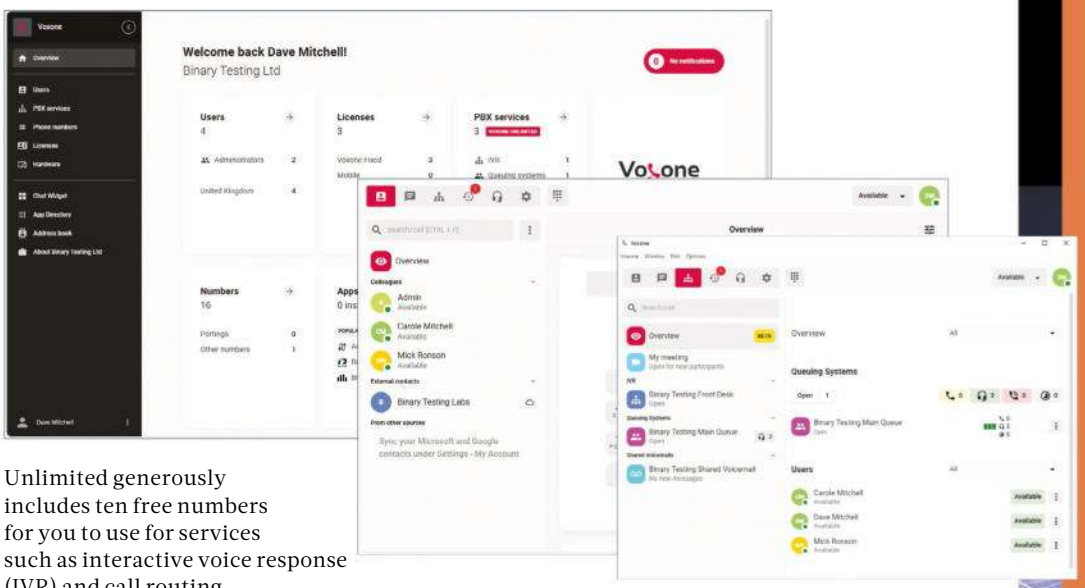
SCORE ★★★★☆

PRICE Starts from £12 exc VAT per user per month from voip-unlimited.net

Voip Unlimited's cloud-hosted Voxone is squarely aimed at businesses seeking a unified communications (UC) solution that amalgamates IP PBX, messaging, meeting and contact centre services into a single platform. Key features are its ability to easily scale with demand and the fact that it's hosted on Voip Unlimited's dedicated network, which is optimised for voice traffic and spread over three UK data centres for resiliency.

Prices start at £12 per user per month, which includes 2,000 call minutes to UK landlines and 2,000 minutes to UK mobile numbers, with separate charges applied for international calls based on each country's call rates. Call statistics and a wallboard display for support staff are available with a CC (call centre) Pro licence, which costs £20 per month but is only required for users that need to access it.

Deployment is a pleasing process. Voip Unlimited did all the heavy lifting for us by setting up an account, creating an admin user and assigning a pool of the external phone numbers we had requested. These can be assigned to users as personal direct inward dial (DID) numbers and Voip Unlimited generously includes ten free numbers for you to use for services such as interactive voice response (IVR) and call routing.



ABOVE **The user web portal and desktop apps present the same interface design**

The admin portal has had a design refresh and presents a clear overview showing details of the number of users and licences, PBX services, phone numbers, installed apps and a basic table of active users. For user onboarding, you enter a name and email address, apply a licence, choose a group membership and assign a DID number from the pool.

Users click on the link in their email invitation, enter their unique authorisation code, set a password and log in to their Voxone personal web portal or download and install the Windows and macOS desktop or iOS and Android mobile apps. One particular feature we like is the user's web portal, while desktop apps have identical interfaces so you can easily swap between them.

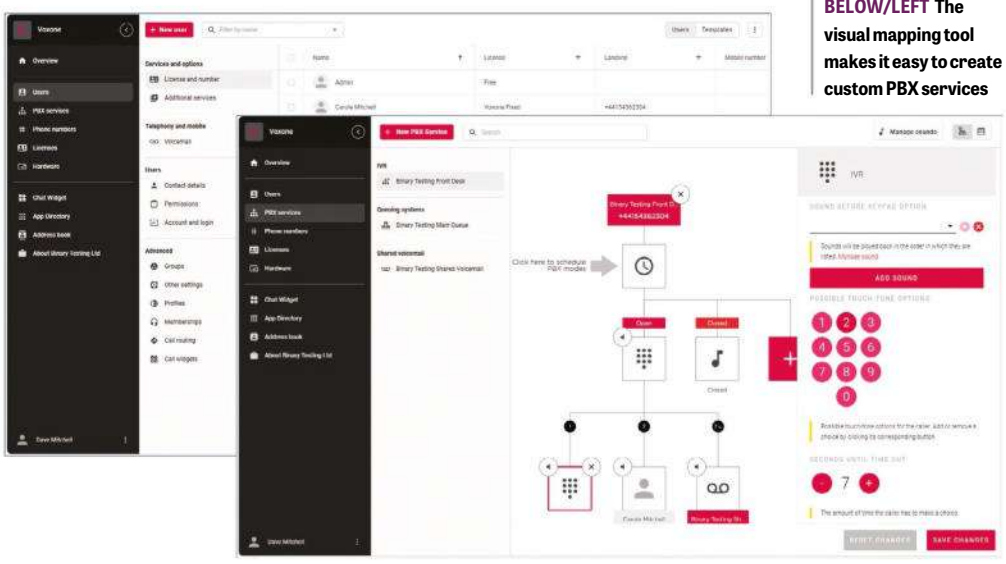
Users can access personal and shared contact lists, make and receive calls, pull up a call history, listen to voicemail messages and sync with their Google and Microsoft calendars. There are plenty of options for handling incoming calls, and Voxone's versatile profiles can be used to create company-specific availability options, with a set of actions that determine how incoming calls are handled.

The user web portal and apps provide integrated videoconferencing features with their PBX service page offering facilities to email a web link to participants, apply a PIN and scan a QR code from a mobile phone. If users want desk phones, that's no problem as they can be provisioned from the admin portal, with Voxone supporting all key vendors including Poly, Snom and Yealink.

Voxone offers around 35 app integrations, including Microsoft Teams, and also has a sharp focus on fixed mobile convergence services. Licensed separately, this allows users to move freely between fixed and mobile networks with no interruptions to calls and is managed directly from the Voxone portal.

"Voxone is a smart unified communications solution that delivers plenty of easily managed call-handling and routing features"

BELOW/LEFT **The visual mapping tool makes it easy to create custom PBX services**



The visual mapping tool is impressive and can be used to create extensive IVR systems along with call queues, shared voicemail and fax-to-PDF services. Once you've added a PBX service, the editor opens a flowchart and menu for setting a schedule, adding voice messages, assigning multiple keypad numbers for different options, routing calls to specific users and sending email and SMS notifications for incoming voicemail.

Voxone is a smart unified communications solution that delivers plenty of easily managed call-handling and routing features. Voip Unlimited makes deployment a breeze, its own dedicated network provides essential reliability, and the product is offered in a range of affordable plans.

D-Link DAP-X3060OU

In need of a firmware upgrade but this Wi-Fi 6 AP is built for life outdoors and comes with free management software

SCORE ★★★☆☆

PRICE £244 exc VAT from cablemonkey.co.uk

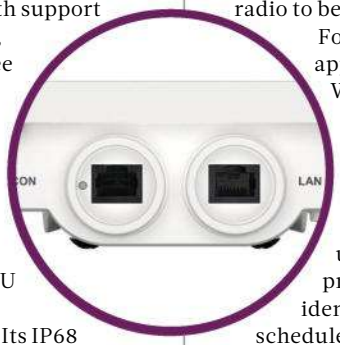
D-Link has traditionally offered two types of wireless access point, allowing businesses to choose between cloud or on-premises management. The DAP-X3060OU on review joins the latter family and, along with support for standalone mode, includes D-Link's free Nuclias Connect software, with a single instance supporting up to 1,000 APs and smart-managed switches.

The DAP-X3060OU can handle the great British weather, too. Its IP68 rating is one the highest achievable and means it's completely dust-tight and can withstand continuous immersion in water. The kit includes wall-mount and pole brackets so it can be easily positioned to achieve the best wireless coverage.

This big AP is well built and its AX3000 rating claims speeds of up to 2,402Mbits/sec on its 5GHz radio and 574Mbits/sec on the 2.4GHz band. Its 2.5GbE multi-gig port requires an 802.3at PoE+ source and the kit includes weather-proof cable glands and slotted caps for the network port and RJ45 console port alongside. Remember to fit the included ESD grounding wire, otherwise you could invalidate the warranty.

When in standalone mode the AP's web console won't win any design awards, but does provide easy access to all key features. The access point defaults to supporting one SSID for both radios but enabling the multi-SSID feature allows up to eight SSIDs per radio to be created.

ABOVE An IP68 rating means that the DAP-X3060OU can survive in the wild



LEFT The RJ45 console and network ports are protected by caps

For each SSID, you can apply mixed WPA2 and WPA3 encryption, enable band steering, set limits on the number of clients that can associate with an SSID and use the intrusion protection scanner to identify rogue APs. A scheduler is also provided so you can set days of the week and time periods when an SSID is active.

For performance testing, we hooked the DAP-X3060OU up to a Zyxel XS1930-12HP 10GbE multi-gigabit PoE++ switch, which confirmed a 2.5GbE network connection and PoE+ power delivery. Our test wireless client was a Lenovo Windows 11 Pro 24H2 desktop equipped with a TP-Link Archer TBE550E Wi-Fi 7 PCIe adapter.

Using Microsoft's NTttcp utility, we recorded raw upstream and downstream speeds of 113MB/sec between both the client and a Windows server on the 10GbE LAN. We had expected more, but D-Link advised us that until it releases a firmware upgrade, the 5GHz HE160 channels can't be enabled when the country is set to EU/UK.

For testing purposes, we changed the AP to US operations and saw our wireless client was connecting over 5GHz at 2.4Gbits/sec. Subsequent runs of NTttcp returned much faster upstream and downstream speeds of 201MB/sec and 169MB/sec.

To test Nuclias Connect, we installed it on a Hyper-V Windows 11 VM with the utility also loading the WinPcap service and a MongoDB database. Its web console presented a wizard to help create our first management site, after which its discovery routine found the DAP-X3060OU and offered to push the default profile to it.

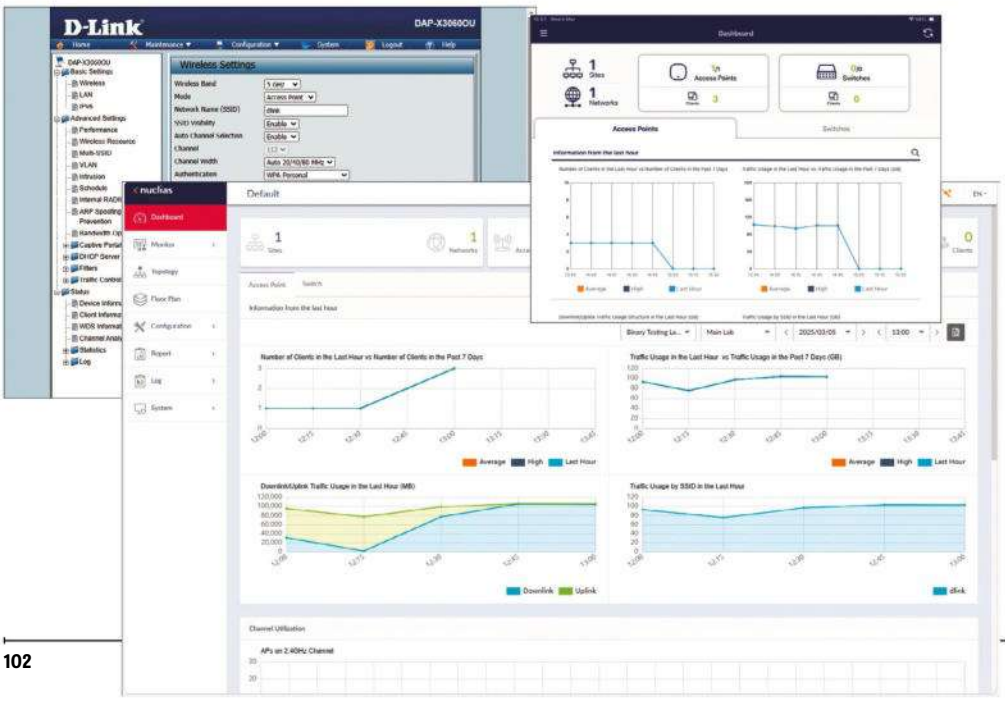
Profiles include everything needed to create and manage your wireless networks and support the same number of SSIDs and encryption schemes as standalone mode. The performance section in our profile had an option to enable the 5GHz HE160 channels, which only worked if we changed both Nuclias Connect and the AP profile to US operations.

"Its IP68 rating is one the highest achievable and means it's completely dust-tight and can withstand continuous immersion in water"

The console's main dashboard provides a clear overview of network activity, with an upper bar showing the number of managed APs and switches plus connected clients while graphs below reveal the number of client connections and details of overall, upload, download and per-SSID traffic. Move to the Monitor page and you can select individual APs, view a 24-hour traffic graph, see connected clients and remotely block them.

The DAP-X3060OU is at the upper end of the price spectrum for outdoor Wi-Fi 6 APs, although value is boosted by the free Nuclias Connect software, which offers good on-premises network management services. The AP's high IP68 rating means it can go where others fear to tread, but we'd recommend waiting until D-Link releases a firmware update that fully supports UK operations. **DAVE MITCHELL**

BELOW The AP supports a standalone mode or the Nuclias Connect software



SPECIFICATIONS

AX3000 dual-band 2.4GHz/5GHz 802.11ax • 4 x internal aerials • 2.5GbE LAN/802.3at PoE+ • RJ45 console • pole/wall mount kits • 277 x 50 x 240mm (WDH) • 1.2kg • IP68 rating • web browser/Nuclias Connect management • limited lifetime warranty

Ruijie Reyee RG-RAP73Pro

Incredibly affordable and very fast, this Wi-Fi 7 AP is a cinch to deploy and includes free cloud management

SCORE ★★★★★

PRICE £201 exc VAT from broadbandbuyer.com

Ruijie Networks' Reyee sub-brand offers SMBs a range of affordable networking products and it moves firmly into the Wi-Fi 7 space with a choice selection of access points (APs). The RG-RAP73Pro on review stands out for a number of reasons, as along with a standard 2.5GbE multi-gig network port it's the first we've seen with a 10GbE SFP+ fibre port.

With a price that's a smidgeon over £200, the RG-RAP73Pro looks remarkably good value. Its big BE14000 rating presents eight spatial streams – two for its 2.4GHz radio and three each for the 5GHz and 6GHz bands, with theoretical maximum speeds of 688Mbits/sec, 4,323Mbits/sec and 8,646Mbits/sec respectively.

A key feature of the Reyee portfolio is all products can be remotely managed from Ruijie's Cloud portal, which is completely free and doesn't require any subscriptions or extra licence packs. UK supplier Broadbandbuyer goes one step further as it offers a free cloud provisioning service, which means that when you purchase a Reyee product, you fill in an online questionnaire and they arrive fully configured and ready to go.

We decided to test over a 10GbE connection and fitted a standard Intel transceiver in the AP. Next, we connected it to the lab's Zyxel XS1930-12HP 10GbE PoE++ switch, which has dual 10GbE SFP+ ports. We already had a Reyee cloud account and, after connecting the AP and providing internet access, it appeared ready for action.

The SFP+ port supports much longer connection distances than copper 10GBase-T, but to use it you'll need a power adapter or a Ruijie PoE injector, which Broadbandbuyer offers for £18. The 2.5GbE port requires a minimum 803.3at PoE+ source, but if an 802.3bt PoE++ source is presented it will happily use this.

For performance testing, we called up a Lenovo Windows 11 Pro 24H2 desktop client equipped with a TP-Link Archer TBE550E Wi-Fi 7 PCIe adapter. Microsoft's NTttcp utility recorded high raw upstream and downstream speeds between the desktop and a Windows server on the 10GbE LAN of 416MB/sec and 325MB/sec.

ABOVE Ruijie's new router is the first AP we've seen with a 10GbE SFP+ fibre port

LEFT The RG-RAP73Pro can be mounted on the ceiling or the wall

BELOW The router delivers great Wi-Fi 7 performance and fine cloud management

Real-world speeds over the SMB protocol were equally impressive. :arge file copies between the client and server returned average close-range speeds of 315MB/sec, dropping to 280MB/sec with the AP ten metres away and in an adjoining room.

Our TP-Link Wi-Fi 7 adapter supports multi-link operations (MLO) using multi-link multi-radio (MLMR), and with this enabled on our site SSID in the cloud portal we saw that the client has created a link across the 6GHz and 2.4GHz radios. It showed an aggregated link speed of 6,106Mbits/sec, and subsequent NTttcp tests saw a modest increase in upstream speeds to 425MB/sec.

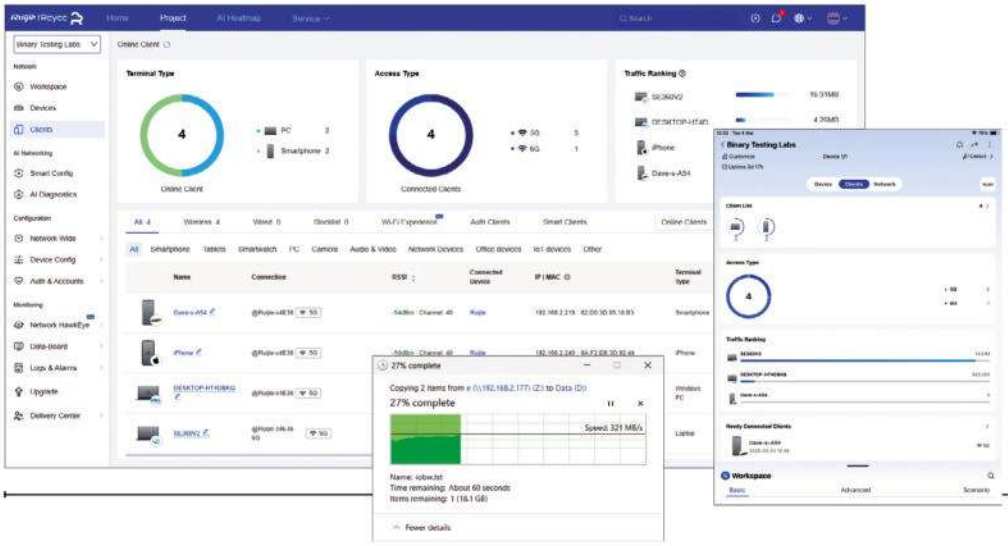
The Ruijie Cloud portal is well designed, with its home page listing projects which represent each site. Selecting one transports you to a Workspace view which shows all associated Reyee devices and topologies plus graphs for wireless rates and Wi-Fi-experience. Quick access icons are provided for creating multiple SSIDs, assigning radios, enforcing encryption up to WPA3, enabling client isolation and setting upload and download rates.

Assign captive portals to selected SSIDs and you can apply a range of authentication methods and customise them with your own logos, background images and messages. Load balancing schemes can be applied to APs and the RG-RAP73Pro supports wireless meshing with other compliant Reyee APs.

"The RG-RAP73Pro scores on all fronts. It delivers a wealth of features and top Wi-Fi 7 performance at a very tempting price"

The portal offers a wealth of monitoring services, with the client view neatly organising devices into categories such as PCs, laptops and smartphones, while the Network HawkEye provides detailed Wi-Fi experience, load and channel health graphs. AI Diagnostics scans the network, highlights faults and provides root cause analysis, with the Data-Board presenting graphical network reports showing areas such as client summaries, traffic rates and AP loads.

The RG-RAP73Pro scores on all fronts. It delivers a wealth of features and top Wi-Fi 7 performance at a very tempting price. Broadbandbuyer's provisioning service makes light work of deployment, and the free Ruijie Cloud service offers top-notch remote management. **DAVE MITCHELL**

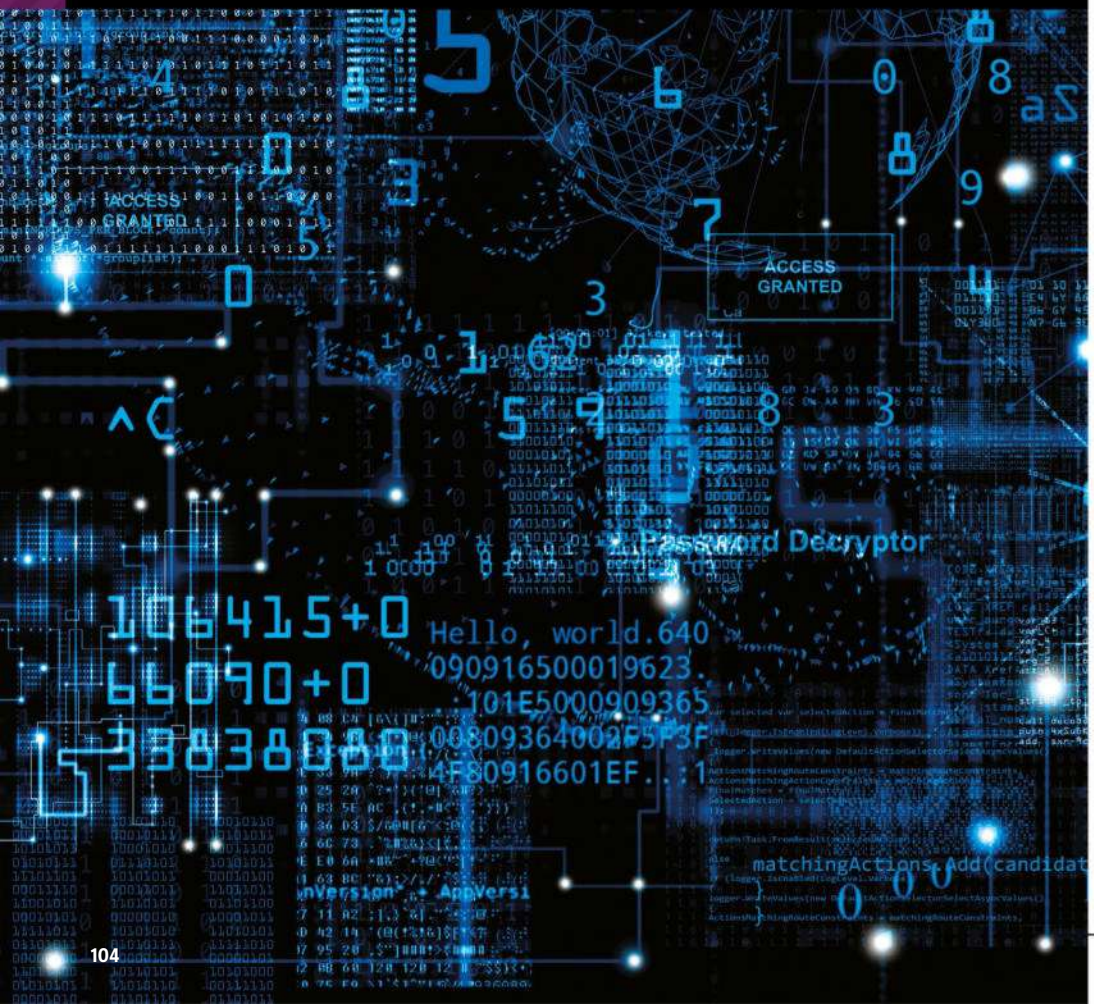


SPECIFICATIONS

BE14000 tri-band 2.4GHz/5GHz/6GHz 802.11be ● 8 x internal aerials ● 2.5GbE LAN/802.3at PoE+ ● 10GbE SFP+ LAN ● ceiling/wall mount kit ● ceiling/wall mounting plate ● 12V DC input (adapter not included) ● 220 x 45 x 220mm (WDH) ● 1.1kg ● 3yr hardware warranty

Remote access: best practice

How do you efficiently and securely allow workers to access resources from wherever they happen to be? Steve Cassidy explores the different approaches and philosophies



The idea of remote access throws up all sorts of security and confidentiality concerns, especially since it's now not just a special dispensation for techies and jet-setting CEOs, but standard operating procedure for staff at all levels. Everybody has been obliged to at least try it out, whether they're working from home or administering remote infrastructure and hardware. The market in remote-access services, products and architectures is absolutely heaving with offerings.

With so many options and scenarios to think about, businesses naturally want to follow best practice, but what does that mean? Of course it's "best practice" to find the right balance between security, cost and complexity, but what that looks like in reality will depend on the size of the company.

The fact is, there's no award or prize to tell the world you really know your remote-access onions. The measure of best practice is all about the non-technical results of your specific implementation. Do you find yourself unduly restricted in daily operations? Are workers having to wait in queues or negotiate with others in order to get connected and get work done? How are your costs comparing to those of your competitors?

In a way, it's freeing to know that you don't need to meet some arbitrary criteria. So, with the understanding that we're not going to uncover a one-size-fits-all standard, let's look at a few facts of remote-access life and consider how to best deal with them.

NAT's the way to do it

NAT – or network address translation – is the trick done by your home router that allows a single external IP address to serve your home PC, your laptop, your smart TV and the Wi-Fi on your hamster's mobile phone. It is anathema to some remote-access systems, which expect to be able to reach out directly to a target device via a unique network address.

It doesn't have to be this way. There's no reason a proper remote-access product shouldn't be able to cope with NAT, but not all can. Some modern services, perhaps aimed primarily at roving laptop users and "diverse" security needs, sidestep the issue by treating the traffic pipeline as a tunnel within a web browser session, rather than as a simple tunnel from one firewall to another. But if a commercial product objects to NATted connections, that suggests they want to do something more intrusive and unpleasant. Best practice here starts with knowing your own infrastructure and the reasons behind its design, so you can confidently reject products and services that don't like it.

Having said that, if you do want to use a service that doesn't interoperate nicely with your existing setup, you could elect to get a separate internet connection that meets its requirements and run the two pipelines in parallel. What's definitely not best practice is undertaking a root-and-branch reconfiguration of every box in your factory with an LED on it just to meet the arbitrary architectural demands of one piece of software.

IPv6? Don't hold your breath

You know those awful reminder posts that Facebook pops up to remind you what you were doing 14 years ago? Occasionally these bring me back to Microsoft events where staffers blithely, effortlessly connected back to their desktop workstations back in Redmond with just a few clicks.

This was partly a showcase of the power of IPv6. Unlike the clever NAT system described above, IPv6 allows every one of the billions of devices connected to the internet to have its own unique address. Frankly, when I first saw Microsoft's demonstrations of remote access over IPv6 I believed the whole field of remote access was sewn up. If Windows could securely, easily and natively allow complete remote control with a few clicks, what more could any competitor possibly offer?

However, IPv6 has singularly failed to take off. On paper it ought to be the critical enabling factor for point-to-point communication across the whole world – or even multiple worlds, given the scale of address space it provides. Even though I'm a greedy gadget hound, who might conceivably hit 50 separate addresses on my LAN on a busy day, there's no way I could ever get close to the number of IPv6 addresses available to me as part of my basic home internet connection: the 48-bit block I've been given would be enough to accommodate every device on Earth, all within my personal LAN.

Yet IPv6 has struggled to gain adoption. This is largely down to the enormous inertia of a public internet that was originally built entirely on IPv4, and perpetuated by the numerous measures that have been taken to ensure that IPv4 remains viable long beyond the point when we expected to have run out of addresses.

As a result, you can't wholly rely on IPv6 to work the way you expect. To give just one example, I spent six months at home unable to see a single picture on a certain large internet auction site because the photo servers were hosted on a native IPv6 server facility, and this didn't quite speak the same language as my Windows Server 2012 OS, which was set up with the default settings for a mixed-mode IPv4/IPv6 home network.

While most ISPs have now figured out how to pass IPv6 traffic through to external destination addresses, few are rolling it out with any urgency, and the ecosystem of remote-access services has grown fully mature under the expectation that IPv6 won't always be available or reliable.

This isn't to say you should write off IPv6, but think of it as a research project – not into how the standard officially works, but how in reality it might be handled by your company's diverse collection of platforms, products and designs. Can you express a static route in IPv6 on your principal border router? What happens with connections via "defensive" DNS servers such as Quad9 or Cloudflare? What happens to the firewalls in crude security models, such as those found on the cheaper type of web and cloud server?

"What's definitely not best practice is undertaking a root-and-branch reconfiguration of every box in your factory"

Actually, these questions are all well worth investigating, whether you have imminent plans to go IPv6 or not. Best practice would be to find out the answers well before you find yourself facing an IPv6 implementation plan.

Keep taking the tablets

This may seem a trifle obvious, but a lot of remote-access connections come from people's homes, often from their family PC but increasingly from an iPad. It's incredible how popular the tablet format is, considering the limited range of remote-access apps for tablet operating systems, and the aggravation factor of remapping a normal desktop PC's panoramic display and input devices onto a compact touchscreen.

And it's not just consumers. Such is the uptake of tablet technologies in the C-suite of businesses large and small that it's not really viable to just say "we don't support tablets", so you need to find a solution that works for you. One redeeming fact is that when people are using tablets they don't normally expect to be able to work exactly as they would in the office; quite often they just want to check a document on their own desktop or the central file server. There's no point in updating your bespoke industrial machine control suite apps for tablet access when the tablet users have no need to be connecting to them.

To reach, or to replicate?

When we discuss remote access, techies like me tend to jump to the assumption that this is achieved by remote control. Of course, for everyday access to the files and applications hosted on a work PC, the easiest and most general-purpose solution may indeed be to extrapolate access to the display, keyboard and mouse.

However, don't overlook services such as Box, Dropbox, OneDrive et al, which synchronise your local file store with a cloud copy – meaning staff can get to their documents from anywhere, without needing to connect to the office network at all.

Of course, plenty of executives use these services all the time, and may indeed consider that they have a "remote control" relationship with their office; it's seldom a good idea to re-educate them, because if all they need is a recent replica of their My Documents folder, who are we to complicate things? Indeed, it's always good practice to have second copies of your documents stored somewhere other than the desktop PC, or the shared-drive server in a broom

ABOVE There are a wide range of factors to consider when planning your company's remote access policies

LEFT Home workers should connect to videoconferencing sessions directly

cupboard – although don't mistake this for a proper backup regime.

As well as simplicity, replication services can be a lot more robust than a full remote-control solution. For example, let's say you've followed my experience a bit more than my advice, and gone with an RDP connection service and Windows Terminal Server as your presentation standard. This requires your remote workers to sign in with their domain credentials, after which the system will deliver remote access via a thoroughly hybridised mish-mash of file replication and screen-sharing. This is fine as long as the user doesn't decide to start surfing the internet, but because of the way RDP works, a badly behaved lump of website code or Trojan downloader can take out the entire RDP environment. You can go from supporting 50 RDP users to a very much in-person onsite rebuild of the platform, just from incautious online behaviour.

Another thing to keep totally separate from remote access is videoconferencing. Remote-access sessions can eat up bandwidth, so almost all apps and services use tricks such as transmitting only the parts of the screen which that changed since the last update. This works fine for a mostly static desktop; it's less effective with live video, which aside from anything else has already been compressed in its own way. Forwarding this through a service that wants to re-compress everything before sending, from an app that wants to service groups of people, necessitating multiple compressing streams of incoming and outgoing data... the outcome is, trust me, no prettier than the description. I've seen businesses pay considerable sums to add another internet pipe and upgrade their firewall and router architecture to make these two high-bandwidth services work together acceptably well.

There's no need for that. Best practice with this situation is to keep videoconferencing out of the remote-access system altogether. Almost all video platforms can be accessed in a browser, so home workers can connect directly from their local devices, and go directly to the cloud VC servers instead of round-tripping both in and out of your main connection centre.

So what is the future?

It feels like we've been asking this question for a long time. For almost the entirety of the 21st century our industry has been looking forward to the promise of a fibre-based internet, running cleanly on IPv6 and using lightweight client devices to access massively powerful cloud-based resources – making remote access either redundant or an unremarkable fact of everyday life, depending on how you look at it.

But progress has come slowly, and not always in the predicted forms. One notable recent innovation is cloud-resident remote-access apps – a configuration in which your head office is demoted to the same status, in VPN terms, as your regular branch offices. The cloud service provider becomes your traffic hub, handling all the grunt work of routing and securing the VPN traffic over which your remote working is presented.

This is a good solution if you're fighting with things we'd hoped to have left behind by now, such as low-spec DSL links, obstreperous suppliers or poorly maintained security configurations. The modern way to do all this is to pretend to be website traffic, encapsulating the VPN packets within HTTP wrappers, so from a technical point of view there's very little configuration required – only perhaps that endpoint devices might need to be loaded with a little network-redirect utility to pack and unpack the traffic from the web browser presentation layer.

"Another thing to keep totally separate from remote access is videoconferencing. Remote-access sessions can eat up bandwidth"

This might be an easier and more pervasive mode of remote access than traditional point-to-point connections, but I wouldn't rush in. With my sceptic's hat on I'd say it's a hack of an unrelated service, and could replace well understood security issues with newer, more obscure ones: best practice, as with any new technology, would be to explore with caution. ●

Remembering Tardis

My first dip into remote access came almost by accident. I'd been trying out the then-new Windows 2000 Terminal Server Edition for another project when a fresh client popped up, asking lots of complicated questions about how to detect all sorts of intrusions, forgeries and unauthorised transmissions inside a Lotus email deployment. While footling around with LotusScript, I made a couple of comments about how I'd been trying out Terminal Services as a remote-access service. My reports were met with a mixture of strong interest and equally strong disbelief: this particular client was a bit too young to remember mainframe teletype terminals, and too old to have started exploring the internet in any depth.

I had a few weeks before I needed the Terminal Server for anything else, so I said, "why don't you give this a quick trial run and see if it does what you're after?" The host machine in question was an ALR Pentium Pro 200, equipped with a server-grade dual-CPU motherboard inside a very beige deskside case. You couldn't find a less impressive-looking computer, so I borrowed from Doctor Who and gave the machine the name of "Tardis", because it was definitely bigger on the inside than the outside.

Despite its grungy exterior, with that early release of Windows Terminal Server this box could host seven or eight remote users, dialling in through a classic 64Kbits/sec ISDN data line. The client was amazed; there were even a few snow days when 20 or so eager non-commuters would try their luck, although in practice one user's web browsing activity would cause the rest of the users to grind to a halt.

What was most striking about the whole setup was how simple it was to offer multi-user remote-access computing using a single server architecture, and I spent quite a lot of the ensuing years not really understanding how less sophisticated third-party solutions had managed to snatch a corner of the marketplace at all. The fact is, these competitors appeal to businesses at different scales, with different budgets and hardware platforms; but regardless of the size and arrangement of your organisation, there's certainly no need to invest in supercomputers and specialist expertise to offer a workable remote-access service.

ISO 27001

Can a single IT security standard apply to all businesses? Steve Cassidy explores an exacting certification scheme

I'm certainly aware of ISO 27001, but what exactly is it?
Simply put, ISO 27001 is an agreed international standard for information security. If you're 27001-certified, there's a reasonable chance that your data is more secure than that of someone who isn't – and that's something potential partners and customers may find reassuring.

How does a company go about getting certified?
It's mostly a paperwork exercise, whereby someone reasonably senior fills in a lot of forms on behalf of the business. To do so, however, they not only need a thorough understanding of how information flows around the company, they must also be able to show that suitable management structures and systems are in place. Getting all of this in order can take anything from a few months (for a company that's already largely shipshape) to well over a year if the business needs to stand up and deploy a new management stack. It's no small task, which is probably why people go to such lengths to proudly display the ISO-certified logo on their websites, invoices, letterheads and so forth once they've got it.

Surely one standard can't work for all businesses, and against all the latest threats?
You might think not, but ISO 27001 isn't about specific scenarios or technologies. Scour its text and you won't find any recommendations on building up a cloud-based cybersecure management suite from diverse vendor platforms – even though many businesses would surely benefit from such advice.

Rather, the standard is all about universal, unchanging principles and processes – a non-technical rulebook, if you will, written by very technical people. Indeed, its full title is ISO/IEC 27001, reflecting the fact that it's jointly published with the International Electrotechnical Commission.

Wouldn't it be more useful if it did include specific practical advice?
There's certainly a place for documents like that – you hold one in your hand – but that's not what ISO 27001 was ever supposed to be about. Rather than trying to keep up with ever-changing technologies, the creators of the standard elected to focus on the timeless foibles and failings of the human beings who operate said technologies. In so doing, they managed to create a standard that's remained relevant and applicable for 20 years and counting.

Even so, you are of course right that there are limits to the usefulness of ISO 27001: because it's so abstracted, some have criticised it as a rubber-stamping exercise that says little about your actual effective ability to handle data-security threats.

And do they have a point?
There is an argument that people qualified enough to be in business and running their own companies ought to be able to handle their own cybersecurity and remediation policies, without going through a costly and time-consuming box-ticking exercise – especially since the certification only lasts for three years.

But as is often the case with these things, the real value isn't in the certificate or the logo. It's in what you learn, explore and document as you work your way through the process. It's impossible to get certified without asking and answering some very direct questions about the way your business operates, with no place to hide behind ambiguities or platitudes. For just this reason I count ISO 27001 certification a definite plus point when sizing up a new supplier or project partner.

Who else manages IT standards?

ITU The International Telecommunication Union takes care of standards that go well beyond phone calls and the like: these guys are responsible for the definition and upkeep of the media formats we use every day. JPEG is one of theirs, as are a grab-bag of video codecs, including the ubiquitous H.264 and H.265 standards.

IETF The Internet Engineering Task Force created and maintains the underpinnings of networks both public and private, by effectively owning the definition of TCP/IP. That's enough to keep a decent workforce of very clever people in work for an extremely long time indeed.

IEEE The Institute of Electrical and Electronics Engineers has the widest remit of any body listed here, presenting a massive portfolio of standards for all kinds of industries and utilities.

SNIA The Storage Network Industry Association is a community of vendors, designers and data-centre operators, focusing on best-practice measures: if the cloud seems to us like a seamless, almost infinite resource, it's thanks to these guys.

W3C Established by Tim Berners-Lee, the World Wide Web Consortium does its best to keep HTML and other presentation layers usable on the web – a short brief, but a big and complex responsibility.

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Real world computing

Expert advice from our panel of professionals

JON HONEYBALL

"To say the software and firmware was buggy would be unfair to bugs. It was a horrible mess"

Truth? You can't handle the truth. Or so developers appear to think, but Jon has a rather different point of view – whether you're small, large or Apple

Let me tell you about an utter outrage. Few things boil my blood quite as much as this. You see, I had an email from Home Connect about its app. The message started off by saying: "With our latest Home Connect app release, we have decided to streamline our digital features within the Home Connect environment, ensuring a more focused and beneficial experience for consumers."

Well, that sounds good. Who wouldn't want a more focused and beneficial experience?

It went on: "Due to technical reasons, the following Home Connect functionality will be discontinued on April 30th, 2025." Oh! Technical reasons, you say? And functionality will be discontinued?

"While the dedicated Smartwatch app will no longer be available, the notification functionality will remain unaffected." What does this mean? Well, the Home Connect app for my Apple Watch is going to be discontinued. The main iPhone app will continue, I presume. But there won't be support for the widget applet that goes onto the watch.

Now I'm sure you're wondering what device this is referring to, and it's at this point that I have to confess to the very definition of a first-world problem. It's for my dishwasher. A Bosch dishwasher that came with built-in Wi-Fi. Being the curious nerd that I am, I connected it up to my network.

In case you're curious, it connects on 2.4GHz in Wi-Fi 4 mode, with a 1x1 MIMO, a receive rate of 135Mbits/sec and a transmit rate of 82Mbits/sec. Over the past 24 hours, it has used a whopping 828KB of data.

ABOVE **Sadly, no longer can I control my dishwasher from my phone**

It has a cloud account, which is what this chatter of data is about, and I can control the dishwasher remotely from my phone. This is useful when you want a delayed start so it runs overnight. It's not hard to do from the dishwasher's user interface, but it's much nerdier to do it from my phone. But very, very much nerdier to do it from my watch, and it seems that this very *Thunderbirds* moment of nerdism is being taken away from me.

I am annoyed – but not by this loss of nerdiness. I know I should take the dishwasher off the IoT network I set up specifically for it and the Daikin heat pumps. No, I'm offended that this is for "a more focused and beneficial experience for consumers". No, it isn't. Moreover, I'm pretty sure the "technical reasons" are that Home Connect, on behalf of its clients at Bosch, Siemens, NEFF and Gagganau, simply can't be bothered to support this any more.

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@jonhoneyball

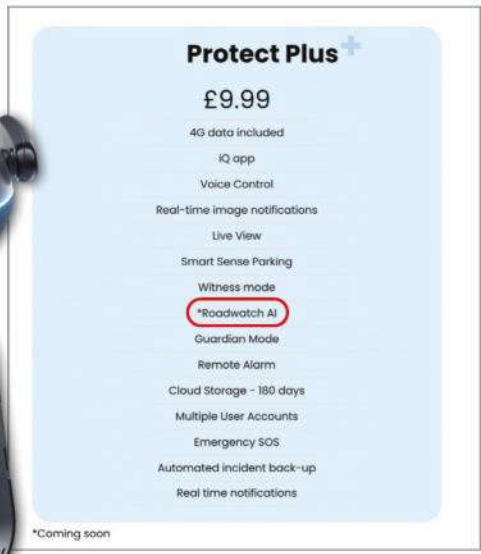
"I have to confess to the very definition of a first-world problem"

Nextbase iQ, feel my wrath

But there is more outrage this month. You may recall how I discussed the then-new Nextbase iQ dashcam which I purchased at the beginning of 2024 (*see issue 355, p110*). To say the software and firmware was buggy would be unfair to bugs. It was a horrible mess. Over the next few months, the firmware and app was improved to at least make it stable. You can tell how missing features were being bolted in: version 1.16.4 on 7 May 2024 finally allowed you to rename the iQ camera to something more appropriate, such as "Audi". After the September update (1.18.4), users could connect their camera to their home or office Wi-Fi, which is useful for anyone in an area of poor 4G connectivity.

However, things have ground to a halt, with 1.19.1 on 5 November 2024 being the current latest version.

There was one feature I was particularly looking forward to try. Called Roadwatch AI, it promised to monitor the vehicles around you and



BELOW/RIGHT **The "Roadwatch AI" feature on the Nextbase IQ dashcam – not coming soon**

Jon Honeyball
Opinion on Windows, Apple and everything in between – p110

Lee Grant
Tales from the front line of computer repair – p113

Olivia Whitcroft
Lawyer Olivia offers legal advice for the tech industry – p116

Davey Winder
Keeping small businesses safe since 1997 – p118

Steve Cassidy
The wider vision on cloud and infrastructure – p120

give enhanced AI warnings and information. There was a flashy video on the product page, but down at the bottom it was listed as "Coming soon" in the section that detailed the effectively mandatory monthly subscription, without which the camera is dumb beyond belief.

Last summer, Nextbase promised me that Roadwatch AI was coming soon, despite "soon" having stretched to well over six months. At CES in January 2025, I spoke to the team from Nextbase. I suggested that they couldn't get the feature to work and it was going to be pulled. They assured me that this wasn't the case, and it would be "coming soon", despite it being well over a year of "soon" at that point.

So imagine my surprise when I looked at the website a few days ago and saw almost every reference to Roadwatch AI scrubbed. It was gone from the subscription panel; the video had disappeared. A quick dip into Internet Archive showed the older pages with everything intact, so I have taken my own archive copy of the video. The forthcoming feature is still listed in the app itself, but that hasn't been updated for months.

I emailed the support team at Nextbase to ask what was happening. They replied with this: "The release of Nextbase's Roadwatch AI speed and distance feature has been delayed due to our efforts to meet the high accuracy standards we uphold. As we continue refining Roadwatch AI throughout 2025, we are also exploring ways to expand its capabilities, ensuring even greater value for our customers. Our commitment remains unchanged – to enhance the driving experience with innovative and reliable technology."

Which reads to me that "we can't get it to work properly", "it might come at some point in 2025 but we don't know when" and "let's promise expanding the capabilities because it's easy to do that when you haven't shipped what was promised already".

To be clear, I never expected this to work in a useful and functional way. I'm not surprised Nextbase can't get it to work. But I am annoyed that the subscription page has, for the past year, been promising "coming soon" for this feature as part of subscription I'm paying for, and I'm very annoyed that the company tried to scrub it from its web page. And to do so with not even an acknowledgment that the feature isn't working and probably isn't coming.

As Queen Victoria might have said, we are not amused.

Brighter Outlook

I have just spotted a couple of handy features in Outlook for Mac, having moved my desktops and laptops back to Outlook after some years being happy in Apple Mail. But I went through a patch a few weeks ago when Mail managed to lose the login information for my various Office 365 accounts, and it was getting boring sorting this out on a daily basis. I like Mail, especially for its "unsubscribe me from this mailing list" feature that Outlook doesn't seem to have.

ABOVE Apple Mail has managed to lose the login information for my Office 365 accounts

But the first feature I found is the ability to delay the sending of an email. I don't mean "send it on Friday". I mean "Undo Send" which allows you to cancel a message after you've hit the send button. This isn't that somewhat awkward "I'm sorry, can you forget the email I just sent you?" that I sometimes get, mostly from PR agents who didn't check their message first.

This setting adds a delay of up to 120 seconds between pressing send and the email actually being dispatched. It goes into Drafts where you can open it up again, when you get that sinking feeling that you've said something quite inappropriate. I'm not sure I will use this feature, because adding delay to emails eats into that natural high-speed flow that emails can provide with a client who operates on a similar real-time vibe. But it certainly would have its uses.

"My Mac Pro, the venerable trash can model from a decade ago, has decided that today is a duvet day"

Composing
Show All
Replies and Forwards:
Indent each line of the original message
Attribution of original message:
None
Include From, Date, To, and Subject lines from original message
Customised attribution format:
Undo Send:
You can cancel a message after you've selected Send
Wait to send messages for
120 seconds
Only available for M365 and Outlook.com accounts
Format:
When replying or forwarding, use the format of the original message
Close the original message window after replying or forwarding
When sending messages, automatically Cc or Bcc myself
BCC
Show CC field by default

BELOW Outlook now lets you recall your message if you have second thoughts

The other feature is a full delay. I need to send some invoices out in a few days, but will be out of the country. Choose Schedule Send and then choose a day and time. The email waits in Drafts and is automatically sent at the time you desire. Of course, dear reader, I know you wouldn't use this to send your boss an email at 4.55pm so you look busy, despite being on your second pint in the pub.

Mac Pro

You know that feeling when you try to get up in the morning and the body isn't willing, telling you that today would be a good day for a duvet day? My Mac Pro, the venerable trash can model from a decade ago, has decided that today is a duvet day. Or rather, Microsoft has decided it for me.

Mine has 8-core Xeon E5 CPUs in it along with 64GB of 1,866MHz DDR3 RAM. The graphics card is an AMD FirePro D700 with 8GB of RAM, and I upgraded the networking with an external 10GbE adapter.

Despite being 12 years old, and owing me nothing, it soldiers on. It's still quite stupidly quick in its daily work, namely running Parallels with a bunch of Windows 11 VMs chugging away. It's excellent at this task, and Parallels allows me to separate out the networking onto alternative hard-wired networking, because the virtual machines are used for testing antivirus software. And that means handling malware.

Its last OS upgrade was to macOS Monterey 12.7.8, which is quite some stretch from today's Sequoia 15.4. But it doesn't really matter, because the macOS part is on its own locked-down network. Parallels still runs just fine, and the virtual machines running Windows 11 don't care. So I've just kept it running, because why not?

However, Microsoft has decided that 12.7.8 is now too old for the current version of Office 365. I can't say I blame Microsoft, but this means it's time to move onwards. Hence my installation of LibreOffice onto the machine so it can still work well with a supported office app.

Chrome, Firefox and Microsoft Edge are still all supported, although I don't know for how much longer. What should I do at that point? For me the cut-off point will be when Parallels no longer installs. I could try the free VMware Fusion, but that will have a clock ticking on it, too. Maybe I should install Linux on it, but this just feels a little grubby. I'll probably allow it to retire gracefully and join the 20th Anniversary Mac and the NeXT Cube and Slab in my personal computing museum.

Or at least, that's what I thought. OpenCore Legacy Patcher (**tinyurl.com/3690pencore**) is a tool that lets you pull together all the parts to patch the OS into thinking that you can run a later version of the OS on it. The instructions are clear with a step-by-step guide to making it work.

It's somewhat tempting to try, although it will require a reformat of the hard disk. And at the moment, the old trash can is still usable on a daily basis with no significant limitations. So I'll park the OCLP toolkit to one side, and wait for the appropriate time.

Recreating Shazam

I love Shazam, a tool that Apple purchased a few years ago. It listens to a small snippet of music and then looks it up in its database. In almost every case, it can correctly identify the source.

I hate hearing something new and interesting and not being able to make a note of what it is. This is especially frustrating when driving. And that is why I have a Shazam button directly on my Apple Watch. One tap and it listens for me, and then adds it to my playlist.

I knew it was doing some sort of FFT (fast Fourier transform) on the snippet and identifying obvious artefacts such as bass beats and so forth. But I had never dug into the research papers behind it.

So it was a delight to come across a programmer who has built a copy of Shazam from first principles. His video (**tinyurl.com/369shazam**) details the process from start to finish.

It's a fascinating ride through programming, algorithms and audio analysis. Even better, he's using this as a demonstration of his programming capabilities, because he has found it difficult to get a job. Getting caught in the endless "you don't have experience... you can't get experience without a job... you can't get a job without experience" loop must be incredibly frustrating.

So I applaud his efforts and hope he gets noticed. He's published the entire source code tree at **github.com/cgzirim/seek-tune** and has a demo at **tinyurl.com/369shazamdemo**. If you're intrigued by the almost witchcraft-like ability of Shazam to identify music, it's worth spending the time going through this project.

ABOVE My venerable trash-can Mac Pro can no longer run Office 365

"I am naturally wary of any system that promises to offer me intelligence"

BELOW One tap of my Apple Watch and Shazam adds the track to my playlist

Intelligence service

There's been a lot of noise on the Interwebs about Apple Intelligence. Or rather the lack of the capabilities that Apple showed last year in various launches. These features have yet to become available to us mere customers, yet Apple continues to punt Apple Intelligence as a key feature worthy of an upgrade.

It's impossible to know what has gone wrong if, indeed, something has actually come off the rails. I use various bits of Apple Intelligence in the apps on my phone and desktop/laptops, but it's hard to know that they're there.

This can be viewed as either a total failure or a major success. I don't want flashy tools that demand my attention or try to get in the way. The email summary tool capability works reasonably well for me, but maybe I just get boring and simple emails?

I am naturally wary of any system that promises to offer me intelligence. The much vaunted "tell me what time mom's plane lands and what restaurants are open on the way back? And make a booking at the one that best fits her palette" sounds great in theory, but life is much too random and complex for this to work for someone like me. And, I suspect, you.

There's an underlying problem for Apple. The competition is touting apps and capabilities that can do almost miraculous things. But notice that much of this is based around information that is out in the public domain. I would be very wary of allowing any of these firms to go

trawling through my entire document history, web history, calendar and emails to try to give me a "Digital Jon". Or, to be clear, I want cast-iron guarantees about who is accessing my data, where it's going and what's happening to it.

Apple claims to be building an AI solution that runs mostly on-device. If it can't come up with an answer, it can pass it over in an encrypted way to Apple's own servers. Only at this point might the question be bundled out to companies such as OpenAI.

At the moment, it seems that nothing is going to Apple's own servers. You can check for this using the tool at SystemSettings/Privacy & Security/Apple Intelligence Report. (This will only work on M-based Apple desktop computers, though.) In the Report Duration box, choose "7 days" and then hit the Export Activity button. This generates an Apple_Intelligence_Report.json file, which you can open up with the text editor. Mine said:

```
\
\
{
"modelRequests": [],
"privateCloudComputeRequests": []
}
```

Which indicates that no requests have left my M4 Pro Mac mini and been sent to the cloud.

Of course I want AI-based capabilities. But I want my data kept private, intact and under my control. I really don't care if this takes more time, because the standard method of "lets suck all data from everywhere, munge it together and hope for the best" is simply not good enough.

You might ponder how this is different to the other items I cover this month, in terms of software non-delivery and removal of capabilities. The simple truth is that I'm not going to compare the lack of a fancy car tracking tool or remote control of my dishwasher with a potential leak of my private and business confidential data. However, Apple has much explaining to do to help reset the expectations of what it can and will deliver, and when. From that perspective, there are similarities across all three issues.

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LEE GRANT

"It's like bolting a Ferrari V12 to a shopping trolley, but it will go like the clappers down the milk aisle"

Lee explains why Microsoft's PC Health Check may be fibbing to you, and why PC upgrades fuelled by Watneys Party Seven are a bad idea

It may not be a surprise for you to hear that the shop has been busy with Window 10 migrations. Broadly, these fall into four main categories: "BIOS upgrade", "BIOS & CPU upgrade", "Have you considered Linux?" and "Please take that antique home and close the door behind you".

Microsoft's PC Health Check app (**tinyurl.com/369health**) has been judge and jury over whether a Windows 10 machine is worthy of a free upgrade, giving a simple yes or no verdict. If you're on a modern Windows platform then you may have seen it. If the decision has gone against you, then I advise doing your homework because PC Health Check isn't always correct. It can only report the status of a machine's current hardware and isn't sophisticated enough to work out the upgrade potential of the components. Earlier this year, we realised that many customers who bought a desktop PC from us in around 2018 would be told their machines weren't compatible with Windows 11, which isn't true.

At that time, the desktops that we built were based on AMD hardware consisting of Athlon and early Ryzen CPUs (and APUs) based upon AMD's phenomenal AM4 socket.

AMD designed this 1,331-pin socket to be flexible and upgradable, and it delivered. AM4 handles three generations of Zen microarchitectures (Zen, Zen 2 and Zen 3) and, despite being launched eight years ago, boards using it remain on sale today. As Zen evolved, so did the AMD Product Codes supported by each generation.

Zen supports Bristol Ridge, Summit Ridge and Raven Ridge, while its 12nm microarchitecture variant Zen+ supports Pinnacle Ridge and Picasso. Zen 2 supports Matisse and Renoir, while Zen 3 support Vermeer and Cézanne. Don't worry, there isn't a written test, but I wanted to demonstrate the breadth of revision supported by one desktop socket, because the technical brilliance of AM4 is its versatility.

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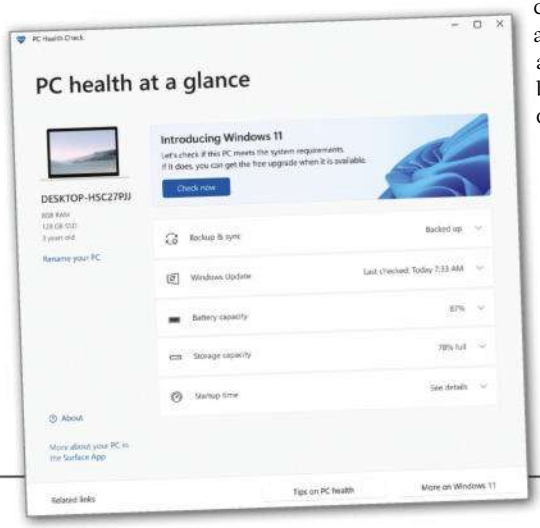
"I advise doing your homework because PC Health Check isn't always correct"

For example, many of the machines that we built used a motherboard such as ASRock's A320M-HDV. Its CPU compatibility range stretches from 2017's Athlon X4 to 2024's Ryzen 5 Pro 5655G, which isn't bad for a sub-£80 component. It will also accept 2021's Ryzen 9 5950X, which is like bolting a Ferrari V12 to a shopping trolley, but be in no doubt that it will go like the clappers down the milk aisle.

ASRock achieved this through progressive BIOS upgrades and many other motherboard manufacturers also embraced this flexibility. This means that all our customers need is a new CPU and a BIOS upgrade to be Windows 11 compatible. Admittedly it's not the cheapest upgrade in the world, but it's less than a new machine, more convenient for the customer and much better for the environment in terms of e-waste. It's a winner in my book.

Getting these machines onto the bench opens upgrade opportunities to add performance. I'd forgotten how many of these units had 1TB SATA spinny drives due to the prohibitive cost of large SSDs at the time. This allows us to "jump the bus" and clone hard drives from SATA (600MB/sec) to M.2 (3,500MB/sec for Gen 3) giving the machine a phenomenal speed boost. One machine arrived as a Windows 10/Athlon 240G/4GB/1TB and left as a Windows 11/Ryzen 5 5500GT/16GB/500GB SSD. The performance



BELOW Microsoft's PC Health Check is not to be trusted when it comes to upgrades

transformation was staggering, and the owner will get many more years of improved usage from the "same" PC.

So, if you have an AMD AM4-based system and PC Health Check is giving you a thumbs down, then a brief investigation is worth your time.

All that glitters is not gold

However, if you bought your system from a top-tier manufacturer focused on short-term proprietary-fuelled profit rather than a friendly neighbourhood computer shop building for long-term customer satisfaction, then the situation may be slightly different*.

When Stephen dropped by with two Win 10 machines, I politely pushed his 7th gen Intel-based laptop straight back at him (I'll explain why in a moment). His HP tower, resplendent with AMD Ryzen case badge, looked far more promising.

It was a Pavilion 590 running a Ryzen 5 2400G, which is a 2018 Raven Ridge chip running on AM4 and ripe for upgrade. Nosing around inside the case, I had concerns about the heatsink. HP's proprietary cooler had an odd mounting system. The standard AMD cooler for this type of chip is fixed in place by four screws, which grip a backplate fitted to the underside of the motherboard. The trick is to push up from the rear while screwing hard from the front (behave!) and, as HP's case has only one removable side-panel, I'd need to extract the board to complete the process.

As it happens, I didn't get that far. Before breaking out the screwdrivers, I needed to check what upgrades the HP Sunflower 8433 AM4 motherboard (**tinyurl.com/369sunflower**) would accept. There was no point offering Stephen a Ryzen 7 5700G upgrade if the motherboard was going to turn its nose up. HP's documentation stated that the most advanced upgrade was a Ryzen 7 2700, which also isn't Windows 11 friendly.

Ever the optimist, and presuming that HP's documentation hadn't been updated, I skipped to the support page to see what was available in terms of BIOS upgrades. "There is no software or drivers available for your product." It's true, there's nothing on the official support site. Want the chipset or LAN drivers? Forget it. It's hard to think how more unfriendly HP could be.

HP hadn't abandoned the machine, but it had failed to publish BIOS updates that would enable it to be shifted from Pinnacle Ridge to Zen 3. Stephen's desktop was forever locked in a Zen state, and not in a good way. The obvious workaround was to swap the motherboard, but HP had made that more complicated, too.

Instead of using standard SATA power controllers, the drives within Stephen's system connect to the Sunflower motherboard via a bespoke 8-pin nonsense socket. Changing the motherboard, PSU and CPU starts to rack up, so Stephen lost interest in the HP, which I fired into my e-waste skip.

As I've mentioned, HP hadn't abandoned this machine. While I was digging around for BIOS upgrades, I noticed that it was still eligible for HP SmartFriend (**tinyurl.com/369smartfriend**). This £89 per year service (including VAT and irony) is HP's tech support service and promoted as "Ready to protect your investment?". Our lawyers have asked me to move on without comment.

TOP Upgrading isn't quite as easy as replacing the sticker, but not far off

ABOVE The drives in the HP connected via a bespoke 8-pin nonsense socket

"Want the chipset or LAN drivers? Forget it. It's hard to think how more unfriendly HP could be"

Welcome to Software and Drivers for
HP Pavilion 590-p0053na
Get Product Support
Choose a different product
See comparable devices
The next generation HP AI PCs
Power your personal productivity with AI that adapts to you
Shop AI PCs
There is no software or drivers available for your product.

LEFT HP's official support website was singularly unhelpful

The Windows 11 hell of Intel

AMD's long-term desktop strategy with AM4 paid off, whereas Intel's didn't. In 2015, Intel introduced the LGA 1151 socket, which supported 6th gen Skylake, 7th gen Kaby Lake, 8th gen Coffee Lake and 9th gen Coffee Lake Refresh. Regular readers will know these better as the Baker, McCoy, McGann and Eccleston variants.

LGA 1151 covered Intel's 100, 200 and 300 chipsets. 6th gen Skylake and 7th gen Kaby Lake support 100 and 200 chipsets, but not 300. 8th gen Coffee Lake and 9th gen Coffee Lake Refresh only support 300, and not 100 or 200. Due to the different chipsets, there isn't a BIOS solution to move a motherboard from a 100 or 200 series up to a 300 series-compatible equivalent. In short, nearly every AM4 CPU will work in an AM4 board, but LGA 1151 has many compatibility roadblocks.

Windows 11 requires a minimum of 8th gen Intel (with the exception of a few Socket 2066 7th gens), which means an Intel motherboard with an LGA 1151 socket and 300 series chipset. If you have an Intel LGA 1151 desktop with 7th gen or lower, the upgrade path that AMD's AM4 customers are using doesn't exist. Come October, you'll have decisions to make.

A-vast problems

The Blue Screen of Death (BSOD) remains a familiar sight in our shop. At the start of the year, a desktop arrived that refused to boot, preferring to display a BSOD and then shutting down. BSODs are usually unhelpful. They will cheerfully display an incomprehensible error code alongside a useless statement such as "A critical system driver is missing or contains errors". Which is it? If the file is missing, then tell me. If it isn't missing... well, you get the idea.

With a refreshing twist, the ailing desktop's BSOD also stated there was a problem with aswVmm.sys, which is part of the Avast Internet Security suite. In all fairness to Avast, its

software had rendered this machine so secure that no-one could access it.

Like most security companies, Avast has an uninstall tool (**avast.com/uninstall-utility**) for when things go awry, but for some reason it's a Windows executable requiring a booting machine to run. As we didn't have that, it's as much use as a waterproof teabag. I spent many fruitless hours running deleted files and remote Registry editing (via a bootable Windows PE environment) in a bid to try an unpick Avast's lock. The furthest I got was to the Windows 11 login screen and then the whole thing died. I'd broken it. Fortunately, before I begin on potentially catastrophic Registry fixes, I always image the drive so I can restore the machine to its original non-functional state. I may not always make things better, but I try extremely hard not to make things worse. The BSOD appeared, indicating that I was back to square one.

Finally, I discovered a sliver of information on a backwater forum where some Avast users had experienced the same issue six months previously. The solution was a throwback to the days of Windows 3. At this point, I had nothing to lose.

The suggested fix was to install Avast Free on another machine then boot it with Linux and delve into the system32\drivers folder. I copied all the newly created files named aswXX.sys to a USB drive (there were around 16 of them) and booted the non-booting machine with Linux. Once the copied aswXX.sys files were transplanted into the system32\drivers folder, overwriting the existing versions (you see BSOD, they weren't missing!), I pushed the reset button and the whole machine fired up. The problem was solved. As a flourish, I uninstalled Avast in the standard way, then ran the cleaner through it to remove any lingering remnants. Despite the fix, I still can't decide what had caused the fault.

Spore-ware update

When Louise brought her teenage son's PC into the shop, she apologised for the condition of the case. "I don't know what he does with this PC." I've learned that this is a statement that not only doesn't require a response but it's better for everyone concerned that one is not given.

Like many teenagers, Louise's son is a gamer on a budget and had been trying to wring all the performance out of the machine to get it play some new game. At some point (details are hazy) his lager-wielding mates had descended into his bedroom and an attempted SSD upgrade and graphic driver update had resulted in a completely dead machine.

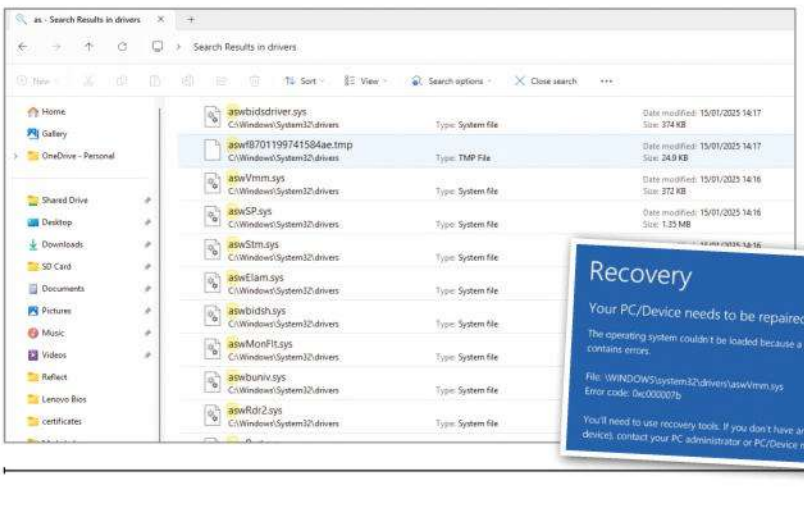
If Louise had been surprised by the outside of the machine, she was lucky to have not seen the insides. There is a powerful line in Alan Moore's *V for Vendetta* where the protagonist assures his victim that he isn't going to kill them because, "I killed you ten minutes ago". This desktop wasn't killed by a bunch of tanked-up teens trying their best, but by a liquid spill that had happened several months earlier and wasn't dealt with.

I'm usually adept at spotting which type of liquid has been dashed into a machine, but this one stumped me. The rear of the dead GPU looked like it had been enrobed with gravy but was now sporting the telltale green sprigs of mould.

I pulled and stripped the card, but I couldn't fix it. Whatever happened on the night that the Charge of the Light Ale Brigade tried to upgrade this desktop had not stopped the goosed card from taking the motherboard's PCIe port, too. However, thanks to some BIOS resetting, I fired up the CPU's on-board graphics and fixed the SSD problem. When Louise collected, I mentioned that although the machine now worked, its days of playing the latest games were over. "Oh well, he'll have to find something else to use this computer for." Smile and nod Lee, smile and nod.

ABOVE The PC wasn't killed by tanked-up teens, but by a liquid spill some time ago

"I may not always make things better, but I try extremely hard not to make things worse"


Search Results in drivers
aswbidsdriver.sys
aswf8701199741584ae.tmp
aswVmm.sys
aswSP.sys
aswStm.sys
aswElam.sys
aswbidsh.sys
aswMonFlt.sys
aswbuniv.sys
aswRdr2.sys
Recovery
Your PC/Device needs to be repaired
The operating system couldn't be loaded because a critical system driver is missing or contains errors.
File: \WINDOWS\system32\drivers\aswVmm.sys
Error code: 0xc000007b
You'll need to use recovery tools. If you don't have any installation media (like a disc or USB device), contact your PC administrator or PC/Device manufacturer.

LEFT The solution was a throwback to the days of Windows 3

BELOW A driver "is missing or contains errors"? That's useful

Small, but beautiful

Finally, a small thing I want to share with you that put a smile on my face. If you've ever removed a sizable GPU, you'll know that trying to release the locking lever on the PCIe slot can be near impossible because it's beneath the card. If you've never done this then imagine that a car's seatbelt release is under the seat instead of next to it.

Recently I worked on a desktop with an Asus X670E-Pro motherboard that featured its Q-Release system. This redesigns the PCIe slot, turning it into a spring-loaded affair with an easily reachable release trigger. It makes the process of GPU removal much easier, therefore reducing the risk of damage.

Although the initial Q-Release had a few complaints (**tinyurl.com/369asusq**), it seems Asus is pushing forward with a new version. It's a very simple modification, which I hope is adopted more widely. With the price of GPUs being so high, anything that helps protect the investment is a good thing.

**This column was sponsored by the Slanderous-Bias Division of the Independent Computer Shop Guild.*

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OLIVIA WHITCROFT

"It's a good idea to keep an eye on the legal pipeline and start planning how it could impact you"

If there's one thing that stays the same in law, it's that the law is always changing. And that's even more true if your specialism involves technology

Changes to the law can be annoying. You've just got your head round the rules, built them into your systems and are sitting back watching everything run smoothly. Then a new law comes along that pulls you back to square one.

A key driver for legal change is technology. Technological advances change the way in which we do stuff, and the roles and perspectives of the different players. Existing laws are not always equipped to address the challenges and uncertainties that arise.

Right now, I'm trying to keep track of several legal developments. Proposed new data protection laws aim to clarify provisions that are impeding the use of new technologies. Applying existing intellectual property law to the use and creation of content by AI is just messy, and the UK government is consulting on how to tackle this. And the Online Safety Act is kicking into gear to mitigate risks of harms that increase as the internet expands.

Data protection

Do you remember back in 2023 (*see issue 349, p116*) I was telling you about the Data Protection and Digital Information (No. 2) Bill (DPDI2), which had replaced 2022's DPDI1 Bill? Well, that one didn't work out either. With some stealthy renaming back to DPDI at the end of 2023, it looked set to be enacted in 2024. But then someone called a general election and the Bill was dropped.

With the new Labour government, there were musings of whether the reforms would stop in their tracks to stay aligned with EU legislation. But my ears pricked up at the announcement of the Digital Information and Smart Data Bill in the King's Speech in July 2024. This didn't emerge either. The House of Lords then put its own stamp on it and welcomed the Data (Use and Access) (DUA) Bill in October 2024.

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"Right now, I'm trying to keep track of several legal developments"

One could be forgiven for thinking that the main debate so far has been over what the new law should be called. But there is some meat to the proposals, too.

The changes I'm talking about most are those impacting the right of access to personal data. A common query is: how far do you need to go to search for data in response to a subject access request? With organisations using ever-increasing amounts and varieties of technology, the potential sources of data are vast.

Let's say you receive a request from a customer. At one extreme, you could halt all other operations in the organisation, and spend human and computing resources searching every system and device (and paper file) ever touched by anyone for any trace of personal data about the requestor. After all, it's always possible a small piece of data is hidden at the back of a drawer somewhere. At the other extreme you could print out the customer's entry in your main database, momentarily ponder as to whether you remember there being anything else, then give up and send the printout.

There tends to be a misconception that if the customer has said: "I want everything you have on me", that you need to take the former approach. But there are limits to required searches. Currently, where an organisation holds a large quantity of data about the requestor, it can ask what information or activities their request relates to. This has always seemed odd to me, as if you need clarification to conduct a search, then why do you first have to demonstrate you hold a lot of data? Your customer may have contacted a particular department, where you can find their records within a limited range of systems. But you also have other teams and types of customer, and who's to say they weren't once your employee, too? Without conducting overly complex searches, you may not know whether you hold any information within other records, let alone large quantities.

The DUA Bill helps with this. It proposes a new rule, which allows an organisation to clarify a request where it "reasonably requires further information to identify the information or processing activities to which a request... relates". This is not limited to where large quantities of data are held. Seeking clarification should also help the individual to get what they actually want, rather than being swamped with irrelevant information.

The DUA Bill also says an individual is only entitled to personal data based on a reasonable and proportionate search (which reflects existing case law and guidance). So you can leave some stones unturned in your search for data. What this means will depend on the context, including whether the individual has been clear on what they are looking for, what significance the data has to them, and what the burdens and costs are in locating and retrieving the data. If the request is unreasonable, there is also an exemption for "manifestly unfounded or excessive" requests.

BELOW Data transfers between the UK, the EU and the US are currently in flux

I'm also keeping an eye on the long-running international data transfer saga. I told you about the EU-US data protection framework (and related UK-US Data Bridge) in issue 359, and that it was already facing challenges. It may be wise to have another plan in your back pocket for data transfers to the US,

particularly now President Trump is giving Executive Orders an overhaul (including reviewing those that form the foundation for adequacy of the framework). Standard contractual clauses may seem an obvious solution, but these also require a transfer risk assessment, which could be impacted by changes to the US regime.

Plus there are rumblings of whether the DUA Bill could impact the EU's determination of adequacy for transfers *into* the UK.

AI and copyright

Intellectual property (IP) rights holders and those training, developing and deploying AI models are struggling to navigate how the law applies to the use and creation of content by AI. There are issues in the use of creative content to train AI, whether AI outputs may infringe others' IP, whether AI outputs can attract intellectual property protection (and, if so, who owns that IP), how consumers can spot that a work is AI-generated, and how individuals can address the risks of deepfakes. There are lots of questions where I don't have a clear answer. This is not because I'm a lawyer and prone to giving cryptic advice, but because the law itself was not drafted with AI in mind.

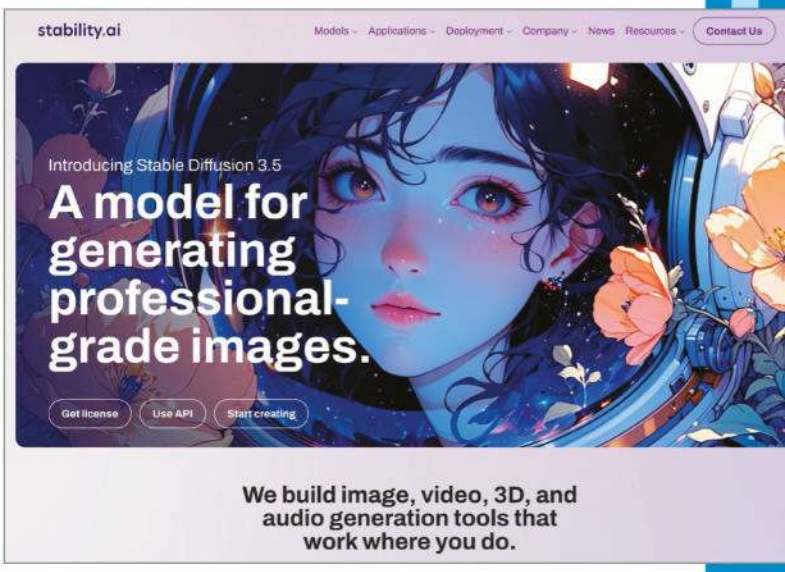
The government opened a consultation on AI and copyright at the end of last year, and the consultation closed on 25 February. An area of focus is the use of works protected by copyright (or related rights, such as database rights) for training AI models.

One option proposed by the government is that AI developers would be able to train on material to which they have lawful access (such as publicly available content), but only where rights holders have not expressly reserved their rights (in which case licences would be needed). This is much wider than the existing exception to copyright infringement under UK law covering data mining for non-commercial research. Mechanisms to support this may include standard tools to reserve rights, individual or collective licensing agreements for payments, and transparency of AI training sources.

I spoke with a company in the publishing industry that thinks this proposal is crazy and doesn't do enough to protect rights holders. In practice, how can they challenge the use of unlawful training material, as it will be too late to back-track? One question posed by the consultation is what the consequences should be of using material where a rights reservation is ignored. Other challenges include limitations on technical controls, concerns over unclear rights reservations, and impracticalities in listing vast quantities of training sources. Indeed, the creative industries have been campaigning against the "opt-out" approach, and in February more than 1,000 musicians released a silent album, *Is This What We Want?*, in protest, with empty studios and performance spaces.

On the other side of the coin, another company I spoke to is desperately looking for clarity on what is permitted so it can make lawful use of publications. It has no intention of depriving authors and publishers of their rights, and is happy to sign up to a licensing model if that is what's needed. But it doesn't want to be taken for a ride by licensing agencies claiming full control of works and charging arbitrary amounts.

Alongside this consultation, the courts are facing the challenge of applying existing copyright law to disputes between copyright holders and AI developers. In the UK, there's a pending High Court case: *Getty Images vs Stability AI*. Getty Images is claiming Stability AI is infringing its copyright (and copyright of its licensors) by using images without authorisation to train its generative AI model, Stable Diffusion. The case started in 2023 and is set for a first trial to determine liability in June 2025.



ABOVE **Stability AI is being taken to court by Getty Images over alleged copyright violations**

"The creative industries are campaigning against the 'opt-out' approach"

Online safety

I've filled up my word count with names of data protection law, so am in rather a rush to discuss online safety. The Online Safety Bill I wrote about in 2023 (*see issue 345, p116*) became an Act in October 2023. As a quick recap, you're caught by the rules if you offer user-to-user services (which means users can share content or communicate with each other) or are an online search provider.

Just over a year ago I drafted terms of service for two new online platforms, enabling messaging between individual users. We envisaged illegal content and age assurance issues, but the finer details were parked pending more information from Ofcom. And now it's here! Ofcom has published codes of practice and guidance to implement the rules, and tools to assist organisations.

Illegal content risk assessments should have been completed by now, and an assessment on whether children are likely to access to the service by April 2025. Where such access is likely, a children's risk assessment should be carried out by July 2025. Age-check methods suggested by Ofcom include photo ID matching, facial age estimation, credit card checks, digital identity services and email-based age estimation.

Another action for providers (which should already be on track) is to ensure terms of service address protection from illegal content, complaints procedures, and rights of users to take action for breach of contract relating to the removal of material, as well as other terms to protect children.

BELOW **Musicians including Kate Bush and Damon Albarn protested against the government's AI plans**

Planning ahead

It's a good idea to keep an eye on the legal pipeline and start planning how it could impact you. There's always a risk that Bills won't become Acts or cases won't be decided as expected, though. If you plan too much too soon, you may need to backtrack. If, following my article in issue 349 (on then-current data protection proposals), you scrapped your process for data protection impact assessments and fired your data protection officer then... oops. I'm afraid these changes didn't make it into the DUA Bill. That must be annoying.

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DAVEY WINDER

"I must be out of my mind even suggesting that 2FA could be past its sell-by date, right?"

Davey ponders the future of multi-factor authentication and has some sage words of advice on recovering your Google account if things go awry

Here's something you've heard said a lot on these pages: "You must employ multi-factor authentication!" Or maybe I've said 2FA as I'm old and have difficulty using such new-fangled and more accurate terms as MFA. But is that advice still valid?

You'd think so, wouldn't you? Consider the sheer volume of threat campaigns employing infostealer malware to firstly grab as many login credentials as possible and then use those already collated in brute force and password-spraying attacks. Also consider how readily available those logs of stolen passwords are. So, I must be out of my mind even suggesting that 2FA could be past its sell-by date, right?

But, as usual, it's complicated, and the cybersecurity devil is very much in the detail. It isn't 2FA that's the problem per se; it's the method used to deliver that additional layer of protection.

It's not you

Regular readers will know that the most obviously problematic method of sending second-factor authentication codes is our old friend the SMS text message. But here comes a whopping big disclaimer: authentication using codes that have been sent by text message provides better protection than no secondary authentication security measures at all.

Read that out loud and absorb just how stupid you feel actually saying it. But there we are, some so-called security experts will advise that 2FA over SMS is the work of Satan himself and almost guaranteed to get your accounts compromised by using it. That, dear reader, is absolute boil hooks (thanks spellchecker) and most everyone knows it.

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@happygeek

"Although QR codes are a more secure replacement, they don't come without risks"

This isn't the same thing as recommending SMS as an authentication code delivery mechanism of choice. The best course of action is to deprecate SMS delivery while replacing it with other authentication methods that are as easy for the end user – heck, even easier in most cases.

It's something that Google has recently confirmed it is doing. I am fortunate to have a number of very good contacts within Google, and during a recent conversation with one of these – whose role covers Google Workspace privacy and security matters – I was told that the use of 2FA code account authentication via SMS is being stopped.

"Just like we want to move past passwords with the use of things like passkeys, we want to move away from sending SMS messages for authentication," Google's Ross Richendrfer told me. "Over the next few months, we will be reimagining how we verify phone numbers; specifically, instead of entering your number and receiving a six-digit code, you'll see a QR code being displayed, which you need to scan with the camera app on your phone."

Now, I'm not the greatest fan of QR codes from the security perspective, especially given the propensity for their use in pretty basic phishing attacks where code stickers can be overlaid atop genuine ones in car parks, for example. I've even seen reports of printed versions sent through snail mail. All of which means that threat actors will surely be investigating ways to compromise this delivery method.

"Although QR codes are a more secure replacement, they don't come without their risks when it comes to multi-factor authentication themed attacks," Mike Britton, chief information officer at Abnormal Security, told me. He added that QR codes are the "most prevalent in fake notifications for multi-factor authentication activity," accounting for 27% of all attacks that Abnormal Security had observed.

While it's hard to imagine that there won't be exploits against such authentication methods, Richendrfer insisted that the use of QR codes "reduces the phishing risk of users being tricked into sharing their security codes with a bad actor, since there's no code to share. In most cases, Google users will no longer be reliant on their phone carrier for anti-abuse purposes." Finally, he added, it "helps reduce the impact of rampant, global SMS abuse".

Which brings me back to what I said earlier: if there's an alternative authentication delivery method,

RIGHT QR codes can help to reduce phishing risks

then use it. Google accounts are protected by a number of different such methodologies, including the Google Authenticator app for generating codes, the use of Google prompts and, best of all, passkeys.

What's that at the back? Yeah, okay, hardware keys are probably the best of all, but if you're talking about the least impact on usability weighed against the biggest impact on security, then passkeys win out every time for me. And, it would seem, for PayPal.

PayPal moves to passkeys

Most of the emails I get purporting to be from PayPal are actually from scamming a-holes. The fraudsters have even found a way of sending their phishing bait using a legitimate PayPal address, just to make things even harder to spot. But, very occasionally, it's the real thing.

Such was the case when PayPal sent me a notification that turned out to be a genuine announcement of a forthcoming change to the way that PayPal protects my account using 2FA. As you would imagine – and expect, seeing as I'm not a hypocrite – I employ a passkey to access most accounts that provide the option, and that includes PayPal. This notification confirmed that PayPal was upgrading the already enrolled passkey, huzzah! So, nothing more for me to do, this would be my default 2FA method.

Not only does this pass the "make security as easy as possible" test, it also makes security sense. Reducing the number of steps involved in the login process while maintaining the validity of multi-step authentication is the natural evolution of 2FA it would seem.

Think about it. Because the kind of 2FA you're used to generates a code on an app, or by way of a hardware key (let's leave SMS out of the loop this time), you need access to that second factor app or device to verify your identity. A passkey isn't much different. Your passkey saves a unique code onto your device that proves it's you, but this time the required second factor is biometric authentication to complete the login.

The slightly more technical explanation is that a passkey comprises a unique public key that is both created and securely stored on the provider platform servers, and a public key that is stored on the end user device. These keys are randomly generated, never shared during the login process, and the public key is used to create a challenge that only the secret, private key can solve.

I know, it sounds somewhat backwards that two-step verification can be achieved using a single step, but that single step involves something you have (your device that stores the passkey) and something you are (your face or fingerprint).

Inevitably, if I write about passkeys being the future in any sense at all, then my inbox is inundated with naysayers complaining that I know nothing. They scream, "What if I lose my smartphone, what if it gets hacked or stolen, what then, eh, eh, eh???" That's a fair assumption to make, I guess, but as my go-to for sage security advice, Joe Lycett, once said: "To assume makes an ass out of you and me."

For a start, your passkey is synced across devices in your ecosystem. It isn't tied to a single smartphone, but to your account. Signing into the passkey provider, whether that's Apple's iCloud Keychain, Windows Hello, Google Chrome or 1Password, should be enough to recover the passkey onto another device. All the necessary protections to ensure that it's you requesting this recovery will have been explained and enabled at the time of creating the passkey, so make sure you follow the instructions when doing so.

Anna Pobletts, the head of passwordless at 1Password, told me that "the website and the passkey provider have joint responsibility to allow you to manage your passkeys and devices – including de-authorising devices or passkeys you don't control any more". Account recovery will, just as with any kind of login and two-factor authentication process, be supported by way of recovery codes or similar.

The argument regarding losing access to a smartphone is moot. What if you lost the smartphone that has your authenticator app installed? What if you lost your hardware authentication key? What if you forget your password? What if the website explodes? Well, maybe not the last one, but you get the general idea.

Enhanced Security with PayPal Passkey update
To enhance security, we're enabling your PayPal passkey as a two-factor authentication (2FA) method.
To strengthen your account security, the passkey you use to access your PayPal account will soon be used for two-factor authentication (2FA). This will make signing in faster by reducing authentication steps. Your current passkey remains valid, and no action is required from you. Previously your passkey was used as one of the two authentication methods with PayPal. Soon, it will verify your login in a single step, making it even easier and faster to pay with PayPal.
2FA is designed to make sure you're the only one who can access your account. It works by asking for additional info, such as a one-time code, on top of your password. Passkeys support this by saving a unique code on your device that proves it's really you, and combining it with a second action like using your face or fingerprint to log-in.
There is no action for you to take. Your current passkey will remain valid and will be used as part of the 2FA process. You can remove your passkey anytime in your PayPal account settings. If you have any questions, please review our FAQ page here or contact our customer support team. More information about 2FA and regulatory requirements can be found here.

ABOVE PayPal moves 2FA protections to your passkey

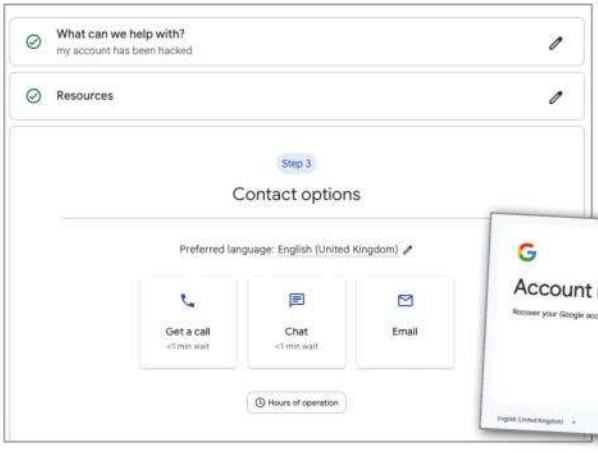
"Another perennial email topic for me is 'my Gmail has been hacked. Help!'"

Recovering Google accounts

Another perennial email topic for me can be summed up as "my Gmail has been hacked. Help!"

More specifically, "I've lost control of my Gmail account to a hacker who has changed the password and associated phone number, I can't get back in and Google is about as much use as Donald Trump at a diplomacy teaching session". To be fair, this is more than a tad unfair to Google. There are numerous methods that Google has available to users who find themselves locked out of their Gmail account, or rather their Google account, as it is this that is at the centre of all things in the Google services universe.

Back to Ross Richendrfer, who has recommended that all users "set up a recovery phone as well as a recovery email on their account" to help with just such hacker tactics. Not least, I am reliably informed, because the account holder can still use the original phone number to gain account control if this is done within seven days of it being changed.



BELOW LEFT Google One subscribers can take advantage of human contact

BELOW RIGHT Try the Google account recovery route before doing anything else

Continued from previous page

All things account recovery start, funnily enough, with Google Account Recovery support. Head to **accounts.google.com/signin/recovery**. I would always advise the use of a device that you've accessed the Google account with before, and the same goes with doing so from a location you've used before and using your usual browser. All these precautions will speed up the recovery process by aiding the identification verification.

One common complaint is that Google help is all online documentation based, or form-driven with no contact to real people. However, if you're a paid up Google One subscriber, you can use the help offered there. This means you can "reach out to Google One support **support.google.com/googleone/gethelp** for help via chat, a phone call or email".

There are no guarantees from me that this will work, but it's certainly worth a shot if you're desperate and the other options have provided little by way of rectification.

There is, however, one final route to recovery, and it's as unlikely as it is apparently effective. Even in a worst-case scenario.

How bad a scenario? What if a hacker had changed your password, recovery email, recovery phone number, two-factor authentication method *and* signed up your now out-of-control account to Google's advanced protection programme? Seems about as extreme as it can get, yet reaching out to YouTube might be the answer.

I say "might" as it's about as unofficial as you can get. Google has refused to directly confirm this whenever I've asked, instead just saying there are multiple ways of recovering an account. From what I can gather, including by talking to people who have used this method, you need to be a YouTube creative for this to work. If you have a YouTube creator account, though, reach out to Team YouTube on X, the official YouTube support team there, and they might DM you asking for a legitimate Gmail address they can contact you on, send you a link to a form to complete, and take it from there. Just don't tell them I sent you...

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STEVE CASSIDY

"While the on-paper specification looked ideal, our real-world experience wasn't so wonderful"

The Heathrow substation fire may not seem a natural topic for an IT column, but it highlights a problem that all IT teams need to address

It turns out that having seven whirring boxes dotted around my basement wasn't necessarily the best answer to my storage requirements. In particular, every so often I need a nice big uninterrupted space for complete images of misbehaving boot drives from servers; laying that out from a mix of 1TB and 2TB bricks using the Windows Disk Manager control suite is theoretically possible, but it's practically impossible once your NAS device count goes much over three.

Time to investigate the latest cool advancements in the NAS sector. What I found completely derailed my search, because things had totally moved on since my previous forage. The first and key enabling factor was the collapsing price of Intel hardware: I found a Dell box with 16GB of memory and a staggering 24TB of enterprise-grade, SAS interface pre-configured disk space for under £350. That's more than twice the amount of space I am presenting here already, and all in one box rather than spread over ten devices (seven NAS drives and three servers).

While waiting for that lovely present to arrive, I took a couple of quick passes around the NAS software reviews and how-to guides, and found myself somewhat staggered by the big metal software now available on frontline hardware. Even three-year-old hardware. It turns out that using CasaOS for NAS and general server management tasks is a leap forward from those old, cut-down Linux days as the NAS standard.

CasaOS requires Ubuntu Server 20 at least – currently it suggests Server 25 – and an optional installation of Docker. Yes, that Docker: the apparently unstoppable cloud platform for container-based virtual machines, with a massive cloud industry following but something of a rep for being a "best thinking caps only" environment. Initially released as a massive data centre/VM orchestration platform, now available on a standalone deskside server near you.

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@stardotpro

"When it comes to emergency power, we're used to IT being the principal customer"

Casa has contradictory tendencies, talking about ease of use on the one hand while also heavily promoting the idea that this is NAS done "your way". That is, NAS for the cloud generation. Most of whom seem to agree that anything to do with Docker or DevOps-based VM deployments in remote or hybrid clouds is a pretty hard intellectual slog. But you can try it for yourself, with a sample Casa VM for you to test drive at **demo.casaos.io/#/** (the username and password are both "casaos"). This speaks of a certain self-confidence.

Right now, I'm eager for progress on my nice cheap server, which thus far won't even light up its network layer to fetch the initial Ubuntu updates. But I do like the idea of grabbing a few Docker images once the basic NAS capability is all settled in. I can then build up a single box that will present DNS/BadGuy blocking a la pihole (**hub.docker.com/r/pihole**) and maybe a nice IMAP-based 21st-century email consolidator – after I've grabbed a few 10GbE cards to bring it up to speed. Downsizing from NAS drives and three big servers down to perhaps one server and two of the newer NASes is too tempting an outcome to give up.

BELOW **You can try out CasaOS via an online demo**

Hotel
Service information
Date FRIDAY 21 MARCH '25
Time ALL DAY
HEATHROW AIRPORT IS CLOSED
THE AIRPORT IS FULLY CLOSED DUE TO A POWER FAILURE AND IS EXPECTED TO BE CLOSED ALL DAY. PLEASE CONTACT YOUR AIRLINE FOR MORE INFORMATION OR HEATHROW.COM

ABOVE **Heathrow was shut for a whole day after the fire**

Fire alarm

Which brings me, in a roundabout way, to the electricity substation fire that took out Heathrow Airport for a couple of days in March. When it comes to emergency power demands, we're used to IT being the principal customer. So much so that it has long been assumed to be an offshoot of the classic IT manager skillset. I'm a lifetime member of the Melted Spanner Club (see below), and chances are that you're far more intimate with the design and testing of power supply systems than most people. In combination, that is, with re-specifying servers and workstations for best runtime when power delivery is not ideal.

Back to Heathrow. As I write, the early finger of blame is being pointed at green initiatives. Apparently, the airport had been well served up until the last round of upgrades, when a green agenda started to influence the choices of backup system.

I'm torn on this issue. On the one hand, thinking like a manager, I can see that striving for green power resources might seem daft if you suppose that the backup resource in question is unlikely to be running for more than a few days at a time. On the other hand, large and powerful generator devices don't take kindly to being left turned off 99% of the time.

My favourite example of this is from the distant past, in a setup that would still be thought of as a decent UPS "component" even now. It was a Napier Deltic diesel engine (check out its Wikipedia entry at **tinyurl.com/369deltic**, if only for its hypnotic graphics), and while the on-paper specification looked ideal, our real-world experience wasn't quite so wonderful. Vast, billowing clouds of black smoke from the exhaust were the norm, and you only had to breathe in a few gulps of that stuff to be instantly "green" in quite another sense of the word.

In Heathrow's case, a few of my friends have worked or advised on the independent power setup at the airport over the past several decades. Some of their disclosures might be too revealing, so forgive the redacted flavour to these observations.

Let's start with a definition. The term "substation" applies to all sorts of blank-sided buildings and compounds around the country. In the case of the Heathrow situation, the substation that caught fire is one of roughly 7,000 distributed evenly across the UK. It has connections to the main grid, and to other, smaller substations, but not to any consumers. Incidentally, lots of these types of transformer device use oil as their coolant fluid. This means there's no such thing as a small transformer fire: once that oil system leaks, catastrophic ignition is almost inevitable.

Anyway, the first revelation was that, at least before the green project, a lot of the uninterruptible power installations were inside the airport fence, and used stationary gas turbines (aka jet engines!) to deliver a complete mains-power replacement level of uninterruptablity. The thing about this is, if you contrast even the most modern of jet turbines with my old friend the Napier Deltic from 1943, when it comes to rapid startup from cold, the old 18-cylinder supercharged diesel has the jet competition pretty much beat.

Take a look at trainspotter movies on YouTube and you'll see that the diesels built into locomotives essentially make a "Grummm" noise and that's it, they're running. Switch over to the aeroplane channels and you'll find there are some jet engines that won't have completely spun up until way after the national anthem has faded out into echoes.

"Once that oil system leaks, catastrophic ignition is almost inevitable"

So here's the conundrum for Heathrow. Everyone likes a nice fast generator startup. Everyone also likes single solution, which is to say that one great big generator is more appealing than, say, 25 mid-sized ones. But it's tricky to have both.

One solution could be borrowed from the UPS installs you'll find in many medium-sized companies. These often have a wall of batteries, kept topped up off the mains supply, there to run for a few seconds as the combustion-powered generators get their show on the road. Having several different types of power generation to fall back on in a staggered fashion isn't news; what is news, driven by that desire to go green, is that a lot of the absolute continuity of supply has been lost.

BELOW **The cause of the substation fire was still unclear at the time of going to press**

Practical steps

Now let's step inside the airport and imagine that you run a sunglasses emporium inside one of the terminals. Something starts messing up the continuity of your mains supply, so what should you actually, really do? As opposed to calling helplines and banging your fist on the table?

The answer is to use a laptop to act as a backup. You might be shocked by the number of vital but basic-level local services you can run

The Melted Spanner Club

This is a secret reference to what you see once you gain access to the power management and supply cupboards hidden inside factories and office blocks. The melted spanner has been dropped on the supply busbars by an inexperienced worker...

on a mid-sized device. Maybe you're not a sunglasses seller but an SME with 100 user accounts. Why don't you find out if you can run a laptop as your secondary on-location domain controller, equipped with NVMe drives and a decent fully wired local network connection? By doing so you would solve one of the most annoying problems with power loss, which is the short blip of total loss of service before the building and site-scale replacements kick in.

A decent laptop able to present 16GB of RAM for use as a domain and DNS device can supply hours of operation, riding out longer and shorter blackouts just on what's left of its original laptop battery capacity.

My personal setup here has two "DC/DNS" service providers. One is an old Mac Pro v1.1, which is definitely not going to stay up during a "blipout". Alongside it is a Lenovo ThinkPad T500, equipped with a third-party battery. Even its aged CPU is perfectly adequate for the laptop to act as a domain controller, and its upgraded SSD storage sweeps away the old objections about laptop disks not being durable enough for the habits of domain controllers.

In this configuration, I can have between four and six hours of mains power outage before my scattered users start getting service access failures. Most of my "blips" in power are more like four seconds, not four hours – but the laptop makes me far less dependent on central power resources. It also eliminates a fair slice of the extra hardware I'd have to be using to support a "proper" server.

For those who don't like the idea of old laptops in vital roles, there are other tricks. Lots of products presumptively labelled as "edge" devices are distinguished by their unusual choice of power connectors: alongside the usual IEC mains inputs you can sometimes find a little blob of screw-post terminals. A row of four set up to take 12V or 24V DC power, as found on vans, trucks, campers and boats. At this level of device, you need to provide the "buffer" function delivered by a laptop battery, but that initial inconvenience becomes a minor matter when you consider that sustained network activity involves power delivery to a lot of other boxes besides your Windows server.

How about all those switches, routers, Wi-Fi repeaters and suchlike? It is possible to build up a network with a whole secondary power supply from readily available basic electrical parts. My only word of warning is that your choice of IT tech device will become progressively more limited as your exotic choices in UPS tech become more and more outlandish.

My solution to this is to keep things small and simple. Don't just tot up all your power consumption measurements and buy the UPS 20% bigger than the final total. It's better to have ten 200KvA UPS boxes, with one sitting beside each network patch panel, router access point, server shelf and printer nook, than it is to try to get the whole building to run off a single generator shaking itself off its mountings with the scale of the demand.

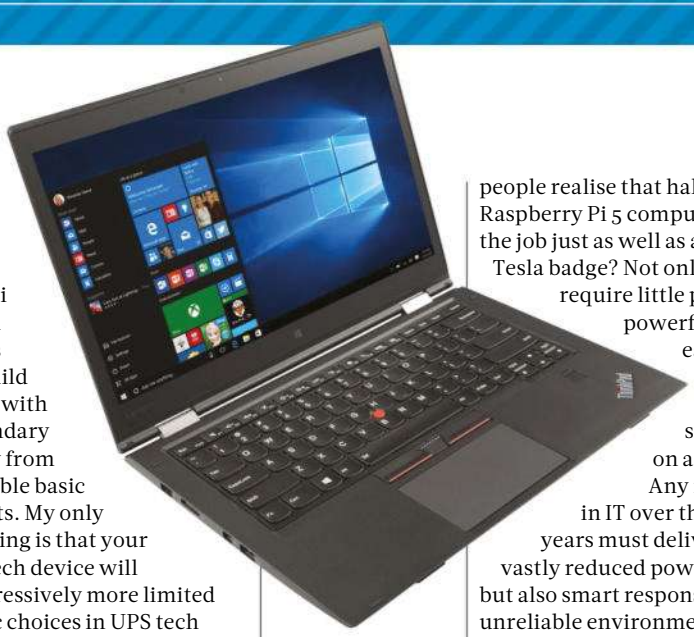
Coming next: get smart

I think it will feel quite strange, in the next few years, to look back at the present-day marketplace in smart devices. Want a small-business-sized intelligent power source controller? It sounds like a reasonable desire, right? Not while the world only has Tesla as a visible brand.

Of course, there are lots of other brands out there dating from the good old days of IT power delivery design – Eaton Power, APC, even Kodak – but nobody else has the level of brainshare that Tesla enjoys. However, Tesla's proposal of mid-sized battery banks scattered throughout a larger site or smaller town is undoubtedly a good answer.

The question is: how far does the cost of smartness in power consumption have to go before people realise that half a dozen Raspberry Pi 5 computers could tackle the job just as well as a box with a Tesla badge? Not only does a Pi 5 require little power, it packs a powerful CPU that can easily manage the response for a mix of smart devices on a network.

Any re-investment in IT over the next couple of years must deliver not just vastly reduced power consumption but also smart responsiveness to unreliable environments. Pursuing this as a main plank of your UPS strategy is one of those things the military call a "force multiplier". That is, it will pay you back handsomely to develop your own responsive computing management when confronted by unresponsive power.



ABOVE An old laptop can help tide you over if power goes down

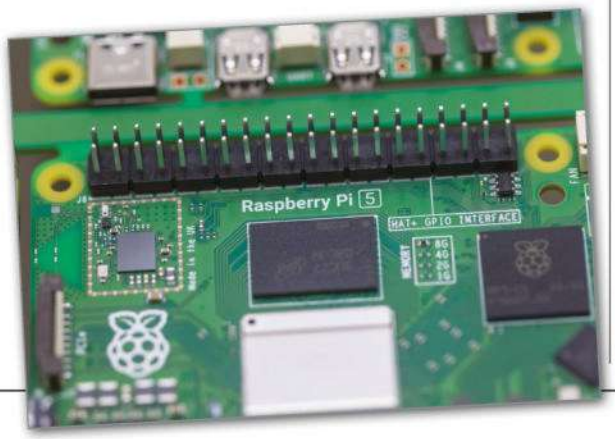
"For those who don't like the idea of old laptops in vital roles, there are other tricks"

Some of this is about obscure wire signalling protocols to rapidly alert all your kit that it had better shut down sharpish and in an orderly manner, in preference to just fading out its LEDs, *Terminator*-style, as the outage poleaxes them one by one. Solutions to this problem are already around us, it's just we haven't looked at them from this perspective before.

To take a simple example, which brings us neatly full circle on how I started this month: I like NAS boxes because most of them provide iSCSI support, and it's almost impossible to break an iSCSI connection just by jiggling the mains power off for a few seconds. The protocol and system has reconnection resilience built in from the very start. It's been around for over three decades, and has performed the same trickle-down move as I've noticed with Docker. Time was when you couldn't have iSCSI without huge boat-anchor rack-mount "filers". Now, I have been able to add a pure software iSCSI Initiator to my Mac Pro server – and Apple really dislikes iSCSI with a passion, leaving it out of all its OS releases thus far.

Only you will know what your network and its myriad devices requires when it comes to power outages. But my key point is that thinking about operating flexibly and in a way that resists the assaults common to the first quarter of this century isn't "someone else's problem". It absolutely defines priorities, budgets, projects and manpower in the IT team. Nobody else is going to fix this stuff.

cassidy@well.com



BELOW A few Pi 5s can do just as good a job as an expensive Tesla-branded box

LEFT **PageMaker helped DTP become a $1 billion business by 1988**

PageMaker: read all about it

PageMaker's release 40 years ago kickstarted a revolution in the publishing industry. David Crookes leaves no page unturned to find out how it all unfolded

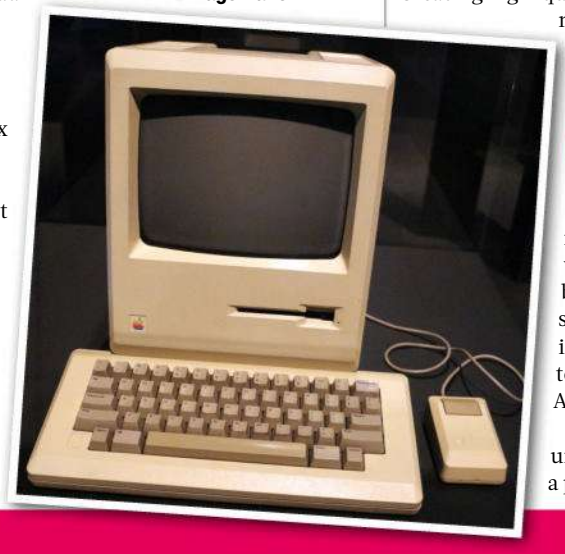
Although Johannes Gutenberg invented the movable-type printing press around 1440, producing professional publications long remained a laborious and time-sapping endeavour. If you wanted to create a newspaper or a magazine for much of the first half of the 20th century, you needed skilled workers to use machines to manually assemble letters into lines – a process known as hot metal typesetting.

Even though production methods gradually became more refined thanks to cold type and offset printing, the process of putting words and images on a page remained cumbersome. As an example, in issue 14 of *Amstrad Action* printed in 1986, there was an article explaining how the magazine was made.

Text would be written on Amstrad CPC 464 and CPC 664 computers using a word processor called Tasword. It was then transmitted down the phone line to a typesetter called Wordsmiths in Somerset. A member of staff would drive over to pick up the finished bromide paper containing columns of text and hand it to the art team to cut up and lay out on large sheets.

It was a semi-manual paste-up process replicated on publications everywhere, with exacto knives and wax being tools of the trade. Camera-ready artwork would be sent to a professional printer and turned into negatives to create printing plates for offset lithography. But every adjustment had to be physical, and correcting mistakes was slow.

BELOW **The original Apple Mac gained a strong reputation among creatives because of software such as PageMaker**



Cut and paste job

Paul Brainerd, who began his career as assistant to the operations director at the Minneapolis Star and Tribune Company, knew there was a better way. He implemented a pre-press technology created by Atex, a company founded in Massachusetts in 1973. Having seen first hand how computers could make a difference to newspaper production, he ended up working for Atex himself in 1980.

In the same way *Amstrad Action* writers were bashing out words on computers, Atex's systems replaced typewriters and paste-up methods with screen-based terminals and a paper-free, server-based system. Newspapers including *The New York Times*, *The Boston Globe* and *Newsday* used Atex, and its impact was global.

In 1986, Rupert Murdoch – publisher of *The Sun* and *The News of the World* – decided to switch his newspapers to Atex. That led to a lengthy, failed strike by print workers and the loss of 6,000 jobs.

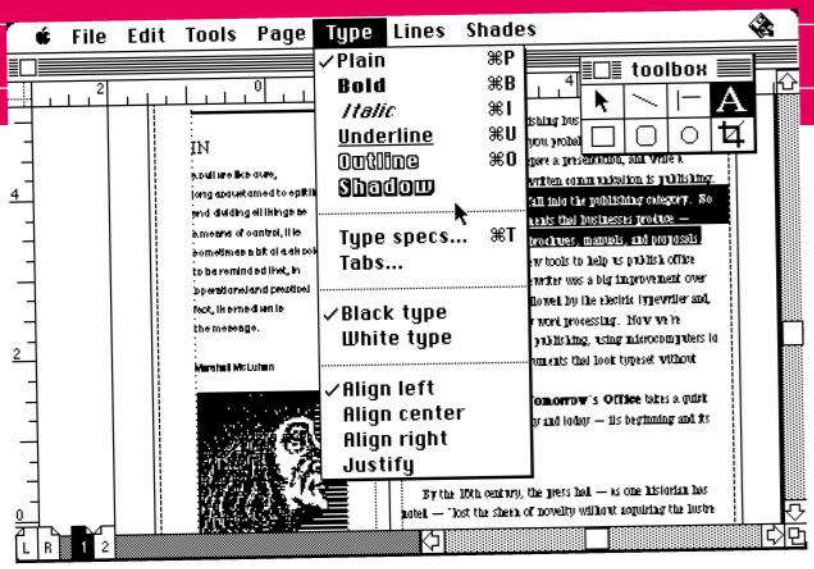
Brainerd lost his own job three years earlier when Atex was acquired by the Eastman Kodak Company, but that proved to be the catalyst for a revolutionary move. He spearheaded the development of a new piece of software called PageMaker that allowed entire pages to be produced on screen, with no need to print off strips of text and no requirement to start manually cutting and pasting.

He called this kind of app desktop publishing (DTP) and, while there were two competitors – MacPublisher and Ready, Set, Go! – PageMaker was the best, eventually changing how newspapers and magazines were created. It also paved the way for ordinary people to get in on the action. Creating high-quality publications no longer required expensive kit and hundreds of workers.

Laser focus

PageMaker's success wasn't entirely of its own making. It was largely due to being part of a wider set of circumstances involving two huge tech companies, Apple and Adobe.

In 1984, Adobe had unveiled PostScript, a page description



language that instructed how digital graphics and text should be printed. Designed in part by the brilliant engineer and Adobe co-founder John Warnock, it allowed precise control over these elements and offered high-quality output to a printer.

In that same year, Apple released the first Mac with a pioneering graphical user interface. It already also sold a 72dpi dot matrix printer called the ImageWriter, introduced in December 1983, but it wanted to produce a relatively low-cost laser printer and was working with Canon on a solution.

Warnock and Adobe's co-founder Chuck Geschke were also planning to manufacture a printer, with a plan to connect to high-end workstations. But Steve Jobs met with Warnock and Geschke, and the plan changed.

The more Jobs discovered about PostScript, the more he liked it, and he asked if he could license the technology to use in Apple and Canon's printer collaboration. Adobe agreed and also dropped plans to make its own hardware. Apple then went on to release the LaserWriter with a Canon LBP-CX engine and built-in PostScript interpreter in March 1985.

The printer was capable of rendering text and graphics at 300dpi, producing output on a par with a typesetter. There was, however, a missing link. It was all well and good connecting a powerful computer to a cutting-edge printer that shared the processing power of a built-in Motorola 68000 chip, but punters needed an application that made the most of this setup.

Contacts book

Brainerd formed the Aldus Corporation to develop PageMaker and it was to be released on the PC. Assisting him were other Atex workers displaced by Kodak's decision to close the facility in which Brainerd had worked – namely Mike Templeman, Dave Walter, Mark Sundstrom and Jeremy Jaech.

"I had been leading the development of a display ad makeup system, a computer-aided design solution for newspaper and display ads, when we were dismissed," Jaech told *PC Pro*. "We thought we could create a similar system for a broader range of page layouts and we were initially targeting small newspaper chains to replace their lead-type process."

The application was modelled on newspaper pagination programmes, one of which had been created by Atex and used at the Minneapolis Star and Tribune. The plan was for users to lay out pages electronically, bringing columned text and graphics together and allowing for different-sized type.

We chose the Mac because it appeared to provide the best platform for what we were trying to build

Publishing consultant Jonathan Seybold knew Brainerd and also worked with Apple and Adobe. This prompted him to suggest Brainerd get in touch with those companies.

When Brainerd did so, he learned more about the upcoming LaserWriter from its product manager at Apple, Bruce Blumberg. He also discovered details about its PostScript engine from Warnock. What he didn't know was that Apple was trying to kill off the LaserWriter, despite Jobs backing it. It was due to sell for $6,995 and that, justifiably, felt too high for retail.

"We chose the Mac because it appeared to provide the best platform for what we were trying to build," Jaech said. And that sentiment was echoed by Brainerd. He told the Computer History Museum in 2006 he had immediately seen the advantage the first Macs would give to page layout (IBM, he said, had "no graphical software interface"). Aldus' decision delighted Jobs immensely.

"At the time, there wasn't any software that could take advantage of the PostScript engine in the printer and it cost twice as much as the HP LaserJet," Jaech said. "So the concept of DTP was created to marry the power of the LaserWriter to PageMaker. It gave companies a reason to buy the printer."

ABOVE PageMaker introduced many of the terms that are now common in desktop software

Producing PageMaker

Brainerd concentrated on the marketing at Aldus while the other four co-founders worked on the software. "The five of us were by far the biggest contributors to the first release," said Jaech.

BELOW Apple's LaserWriter came with a Motorola 68000 processor

"At that time, software for the Mac had to be developed on an Apple Lisa, and we could only afford two of them, so two developers had access to the Lisas from noon to midnight and the other two from midnight to noon. I slept under my desk many times, as did the other developers."

The aim was to produce an intuitive yet rather complex program, inspired by MacDraw and MacPaint, that would be aimed at small businesses, offices, churches, schools and small publishers. If PageMaker had been aimed at the professional newspaper and magazine market immediately, he knew it would fail because decision-making at such companies tended to be slow.

Even so, PageMaker introduced many features used by professionals today. Rulers showed measurements in millimetres, inches or picas to allow accurate placing of the various page elements. There were drawing tools and a function to resize and crop graphics, plus a feature that allowed text to be bent around images.

"PageMaker brought a newspaper layout concept to document creation, the idea that a document consisted of graphics (display advertising in newspapers) and that text flowed around the graphics in 'text holes'," Jaech said. "That is why the 'place' command, which flowed text into a text hole the user chose with the mouse, was the most important feature."

Text could be spread across as many as ten columns of various widths, with leftover words automatically flowing to the next column. Users could change type styles and fonts, page numbering worked automatically, and it was possible to view the screen in full or to zoom in and out by as much as 200%.

"PageMaker introduced users to typography concepts like font, font measurement systems, font families, letter spacing and leading, even kerning, and other advanced concepts," said Jaech. "It taught the idea of assembling a series of pages from parts created by other programs. It introduced columns and margins. It opened up the capabilities of professional printing systems and made them accessible to everyone."

Documents were limited to 16 pages at a time but they could be linked to

form larger publications, which got around such restrictions. PageMaker would also double as a simple word processor (although many experts suggested writing text in a dedicated app such as MacWrite and importing it).

Users didn't necessarily have to keep jumping between programs, though. All text could be edited within PageMaker and any alterations would simply cause text to reflow. It was also possible to create master pages, and users could make use of MacPaint and MacDraw files. Just as importantly, while the PostScript files created by PageMaker could be sent to the LaserWriter, they could also be read by Linotronic typesetters.

It's no surprise, then, it was so well received on its release in July 1985. A few months later, *InfoWorld* magazine went so far as to say: "PageMaker, together with the Macintosh and the LaserWriter, may become the program that establishes desktop publishing as the new necessity."

The review praised the program for being intuitive, saying it could be learned in half an hour, and even a stiff $495 price didn't dim its enthusiasm. "PageMaker is expensive but this is no lightweight program," the article concluded. "In its way, this could be the Lotus 1-2-3 of business desktop publishing; its combination of powers and potentials make it very good value in its market."

Design notes

Aldus had struck lucky. The three stars – the Mac, LaserWriter and PostScript – had aligned at just the right time. "Apple also paid for the marketing of the combined solution since every time we sold a $500 PageMaker, [it] sold about $15,000 worth of hardware," said Jaech.

This meant Aldus didn't have to spend development money on promoting its program. "We gradually added staff for customer service and operations," Jaech explained. Before long, people were snapping up the program and buying into Apple's publishing ecosystem, discovering they could produce high-quality brochures, newsletters, magazines and reports at a far lower cost than before.

The what-you-see-is-what-you-get approach worked wonders for this fledgling sector and there are multiple stories of people who say they owe their careers to PageMaker.

Terry White, principal director and creative cloud evangelist at Adobe, recently posted on X saying the PageMaker, Mac, LaserWriter, PostScript combination prompted him to quit his job and open a desktop publishing business. "Traditional typesetters on Compugraphic laughed at me and my 300dpi output and thought it would never replace what they used," he wrote.

Yet some of those naysayers were likely acting out of fear for their jobs – or they were looking at some people's PageMaker designs with despair. So many PageMaker users were making a dog's dinner out of their designs using every font or effect at their disposal.

This wasn't Aldus' fault, nor anything to do with the tools, but the "ransom note effect" – the result of using too many typefaces – and a poor eye for what looked good on the page. Help was required.

So marketing expert and author Roger C Parker approached Aldus and proposed a slim book that explained the basic elements of design, which ended up being given away to PageMaker's registered users. Parker followed it up with the bestseller *Looking Good in Print: A Guide to Basic Design for Desktop Publishing*. Magazines also ran tutorials giving readers a grounding in design.

BELOW Adverts for PageMaker highlighted its speed, economy and ease of use

BOTTOM Hot metal typesetting was used in professional publishing before the arrival of DTP

The next page

Aldus created further versions of PageMaker and it led to a growth in small-scale and independent publishing from local magazines to fanzines. In that sense, it democratised publishing and sped up the production process, allowing for greater design experimentation and giving publishers and writers greater control over their work.

"Many things were published that would never have been published using the old gluepot and exacto knife page paste-up method," said Jaech. "We knew we had a winner when we surveyed our customers to ask what they were creating with PageMaker and got back a wide range of answers."

Yet PageMaker's success was not to last. While it had a good run (and soon appeared on the PC), other companies weren't going to allow it to dominate. By the end of the 1990s, it had effectively lost the professional market while the LaserWriter was losing out to more cost-effective models with comparable features.

QuarkXPress became a major competitor, and Adobe ended up buying Aldus in 1994 before producing its own rival, InDesign, five years later. Adobe continued to produce PageMaker up until version 7.0 in 2001 but brought down the axe in 2004, just short of its 20th birthday.

By then, PageMaker had done its job. "It set a standard for what a good-looking page should look like," Jaech told us. "The word processor makers all took the ideas into their products and people just expected printed material to look better than it had in the past.

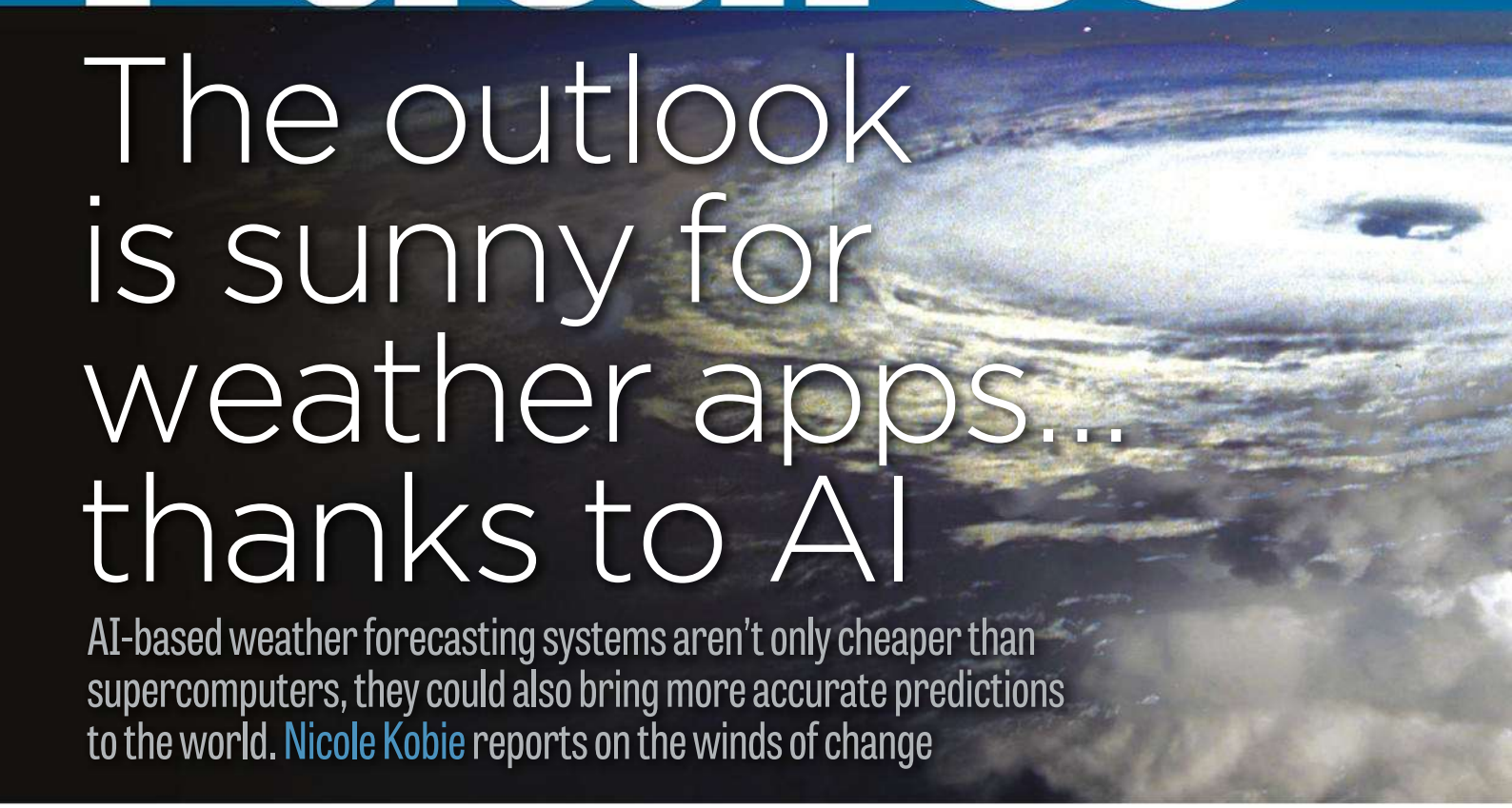
"Users learned about fonts, font families, font size, letter spacing and so on and then expected to be able to control those and many other type characteristics in the products they used."

Such lessons continued beyond print, influencing how websites are created. The design literacy fostered by PageMaker is also sure to live on for many more years to come. ●

Every time we sold a $500 PageMaker, Apple sold about $15,000 worth of hardware

Images: @arkivum/X, Apple, Wikimedia Commons, Sailko, Wikimedia Commons, CC BY 3.0, Wikimedia Commons

Futures



The outlook is sunny for weather apps... thanks to AI

AI-based weather forecasting systems aren't only cheaper than supercomputers, they could also bring more accurate predictions to the world. Nicole Kobie reports on the winds of change

Look at your weather app and it says rain soon – and then you end up carrying an umbrella in the sunshine. Or, more likely in this country, the app predicts sun and you end up drenched. What if weather forecasts were more accurate?

Now imagine you live in a country that doesn't have access to its own weather models and relies on systems designed for other parts of the world. Local storms can't be predicted and seasonal forecasts required for agriculture aren't accurate enough.

There's a solution and, predictably, it's based on AI. Less predictably, it's called Aardvark – an AI-based system that ditches supercomputers and allows local models to be run on a desktop by a single researcher.

The prediction problem

At the moment, weather forecasts are generated in a multipart process using supercomputers. Each section can take several hours to run, and requires large teams of experts to use, develop, maintain and deploy. That means weather prediction is expensive and time-consuming, effectively cutting it off for countries without the means to own and operate supercomputers.

Ghanaian meteorologist Michael Baidu is currently a research fellow at the University of Leeds. "We do not run our own models, mainly because of computational costs and how much power is required to run these models," he said, speaking at the Turing Institute's AI UK conference.

The challenge is exacerbated by unstable power supplies; if it cuts out part way through a model running, the whole process must begin again. "So we've mainly relied on the global north for the output of the models that we use for forecasts," said Baidu.

That includes the Met Office, the European Centre for Medium-Range Weather Forecasting (ECMWF) and the US National Weather Service. "Those models have mainly been developed for the mid-latitudes and not for tropical latitudes, so they are not able to simulate tropical storms accurately," Baidu explained. "That's one reason why we have a need to get models that run at a higher resolution over Africa that best suit African weather, which is a challenge because of the computational costs involved in running these models."

Caroline Bain, head of verification, impacts and post processing at the Met Office, said organisations such as her own are improving model data for parts of Africa, but it's worth supporting countries such as Ghana to build their own systems. "One of the things we're really excited about with AI is there could be more resilience in some of these countries, so they have the opportunity to own some of these models themselves rather than be too dependent on the global producing centres that are generally in the global north," she said at the conference.

Swapping out supercomputers for AI

AI has been applied to individual parts of that supercomputer-dependent process already, notably with research by Huawei, Google and Microsoft, which replaced the numerical solver that calculates weather over time.

Richard Turner, research lead for AI weather prediction at Turing and a professor of machine learning at the University of Cambridge, explained that current numerical weather prediction works in three separate stages. First, information is gathered from weather stations, satellites, boats and so on, then run through models to create an estimate of the current state of the atmosphere.

Second, a physical model is run to predict how the atmosphere is going to develop over the next few hours, days or weeks; this is based on physics, notes Bain, with known processes

It's not like data in other parts of machine learning science – it's incredibly clean and noise-free

such as shallow water equations and fluid dynamics applied to the information. "This makes predictions everywhere, in a relatively coarse way, around the globe," added Turner.

In the third stage, known as post processing, those coarse predictions are applied to smaller areas to allow a forecast for a specific location.

AI has been applied to the second step with a lot of success, helped by incredibly clean data sets of weather conditions provided by organisations such as ECMWF. "It's not like data in other parts of machine learning science, which has privacy concerns attached to it or missing data – it's incredibly clean and noise-free," said Turner.

Machine learning researchers took that remarkable data set and used large language models (LLMs) with transformers. These are the same sort of systems that power ChatGPT et al, but here they're designed for vision and look at historical numerical weather data as though it's an image. They can then forecast what's coming next, the same way a text LLM predicts the next word in a sentence.

Fully trained up, Turner said it worked as well as – if not slightly better than – the best numerical systems. "But this doesn't take a supercomputer to run that step, it takes a few GPUs," he said, though he admitted training was expensive. "You're replacing the work of a large team that has to develop these things over many years and maintain them with a supercomputer that's very expensive, and reducing those costs by a thousand or ten thousand times, which opens up a vista of new opportunities."

Work continues on this style of AI weather forecasting, with the ECMWF's strategic lead for machine learning Matthew Chantry saying the organisation was now using such a system to make daily forecasts. This means meteorologists can compare that tool to existing systems to better understand how it works.

An AI solution in Aardvark

That's one part of the system replaced with AI – but you'll still need a team of researchers and a supercomputer to manage that first step, taking the collected data and building a model, leaving the wider problem unsolved.

What if you replaced the whole process with AI? That's what a team of researchers from the University of Cambridge, Alan Turing Institute, Microsoft Research and the ECMWF have managed to do, led by Turner.

TOP The AI-based Aardvark system can be run on local computers

ABOVE Aardvark pulls in data from a variety of sources to create forecasts

They created a single machine learning model called Aardvark Weather that cuts across all three stages, trained end-to-end to take raw data and make forecasts. "If you can do that, then you can run these things on GPUs or desktop computers," Turner said, and that means countries such as Ghana can not only run their own models, but can make predictions on challenges that specifically impact them.

Building the initial system was no easy task. Simply pulling in the relevant data took two years of a student working with organisations around the world, with the data processed through different types of machine learning.

Once trained, it pulls in weather observations from satellites, weather stations and other sensors to create forecasts in minutes. That means it's faster and cheaper than existing supercomputer-based systems.

But Aardvark is also more accurate – even using less data. When pulling in only 10% of the data used by existing systems, Aardvark Weather already outperforms the US national

Aardvark's breakthrough is not just about speed, it's about access

GFS forecasting system on some variables, and is comparable to the US Weather Service. "In accuracy, people have estimated that you can get two to three days extra improvement in the efficacy of your forecast, so your forecast at three days will be as good as your forecast at one day ahead if you can use these new techniques," Turner said.

Douglas Parker, professor of meteorology at the University of Leeds, noted that the limits on accuracy are as yet unclear. "We do know that there [are] some fundamental chaotic limits on how far you can predict the future in our chaotic world, but certainly we are seeing these new models pushing the boundaries beyond what we can currently do," he said.

Access for all

Creating bespoke forecasts using existing systems could take years of work, meaning Aardvark could open up weather tools to countries that previously didn't have access because of the high costs involved.

"Aardvark's breakthrough is not just about speed, it's about access," Dr Scott Hosking, director of science and innovation at the Alan Turing Institute, said in a statement. "By shifting weather prediction from supercomputers to desktop computers, we can democratise forecasting, making these powerful technologies available to developing nations and data-sparse regions around the world."

The simplicity of the system means it can be easily adapted for specialised forecasts for a location or industry – such as wind speeds for a renewables company in Europe, or temperatures for agriculture in Africa.

Indeed, as Parker notes, rather than training with a European or global focus, it can focus on a specific region. "Smaller teams with smaller computers can be creating, delivering and innovating the forecasts themselves," he said. "Designing and training solutions in Africa for Africa – that change is really fundamental."

What's next

Next, the researchers building Aardvark Weather will set up a team within the Alan Turing Institute specifically to figure out how to get the system into use in developing countries and to apply it to a wider range of environmental conditions.

"These results are just the beginning of what Aardvark can achieve," said Anna Allen, lead author from the University of Cambridge. "This end-to-end learning approach can be easily applied to other weather forecasting problems, for example hurricanes, wildfires and tornadoes. Beyond weather, its applications extend to broader Earth system forecasting, including air quality, ocean dynamics and sea ice prediction."

Beyond Aardvark Weather, the growing accessibility of weather forecasting means the market is opening up to private companies rather than just national government organisations, says Parker. "The private sector has been very active," he said, adding that it's no longer huge companies but SMEs, too. "I don't present that as good or bad, it's just this is the state of how things are changing. The next two or three years, we're really going to see the implications of that."

And the winds of change are certainly blowing. As Turner notes, weather forecasting has been relatively static for decades, but in the past three years it has been completely transformed by AI. "There are incredible opportunities across the whole of Earth systems forecasting as a result," he said.

ABOVE Getting data from Antarctica is a real challenge, but AI can help

AI for polar frontiers

With climate change in mind, we need to know what's happening to polar regions. Is the ice receding? What's the weather like, beyond freezing beyond all comprehension? How are marine environments changing?

As we've seen with weather forecasting, AI can sift through data to make the necessary predictions to track the damage we've done to polar ice. But first we need to get the data.

James Byrne, research software engineer lead at the British Antarctic Survey (BAS), said the trick is getting data out of a very hostile environment. "It's a lot of fun working down there, but you don't have mobile networks, it's done by satellite or going to get an SD card out of an instrument that just overwintered in minus 50 conditions in blowing snow all year round – so that data becomes extremely valuable," he said.

BAS uses AI to examine how to improve operations so they're less carbon-intensive, but also to help fill in missing data – it's impossible to get it all in such conditions.

But once we have it, we can apply it to better understanding that environment. Louisa Van Zeeland, research lead at Turing, works on IceNet, which forecasts sea ice with 95% accuracy two months out. "In IceNet, we have three data sets combined together into a unit source and into the model," she said at AI UK. "What I want to do is look at all these data sources, how do we find a probabilistic way to combine them going through multiple AI models that chooses the best way forward."

Edward Steele, science manager for marine applications at the Met Office, notes that bringing together multiple data sources to improve decisions is one of the most undervalued uses of AI – not just lowering costs, speeding up calculations or otherwise improving efficiency. And that's especially true when working in a region where data is tough to come by.

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Features

Code your own app in AI

Whether you're curious about how AI can bring your ideas to life or you've always wanted to create your own software – including games – we show you how.

Features

Create your own calendar

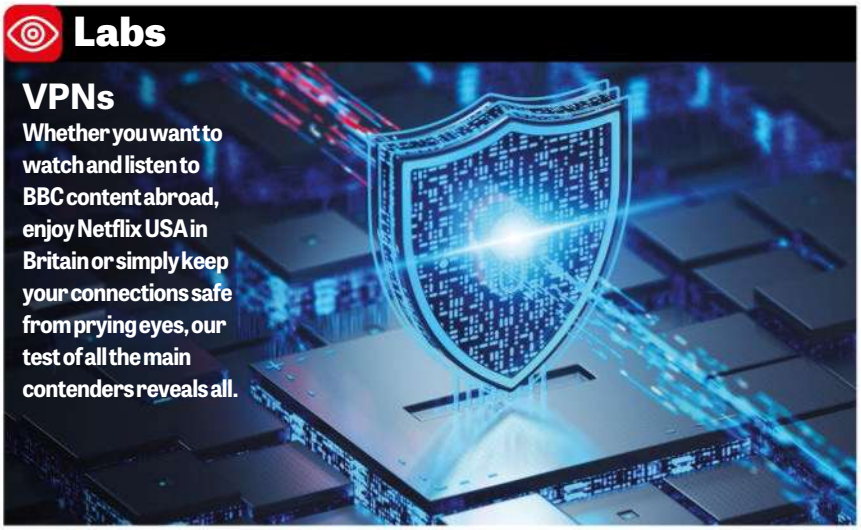
Fed up of AI but still want to code? This partner piece to our main feature shows how one programmer created her own self-hosted calendar.

Features

Instant Expert: Microsoft Designer

Copilot describes Microsoft Designer as a graphic design app powered by AI that helps you create professional-quality visuals. More usefully, we explain how to use it.

Labs



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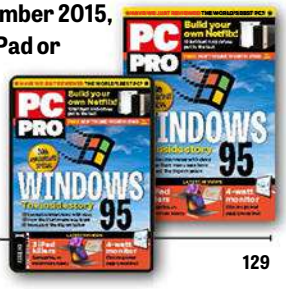

Please note: Labs and features are subject to change

Don't start a trade war when you know nothing about trade, demands Jon Honeyball

We are in the centre of a trade war storm the likes of which we have never seen before. President Trump has decided that he knows best, and that international trade can be reduced to a few simple sums in a spreadsheet. I'd suggest using a slide rule, but I suspect log tables are a little beyond him.

Part of this enormous upheaval is the imposition of large tariffs on goods exported from China to the USA. Well, that might change by this afternoon, as it has twice already in the past few days. But let's just run with the concept of tariffs on imported goods.

The logic, thin as it might seem, is that forcing tariffs on the likes of Acer, Apple, Audi and almost all other vendors, will push them into moving manufacturing to new sites within the USA, and that would be A Good Thing for American jobs.

The naivety is almost without limit here. Let's just start with the obvious issues – how long do you think it would take for Audi to set up a new car plant in USA? To have it operational and ready to deliver new vehicles? Shall we agree that five years is probably being overly optimistic? How long might it take Apple to have a new factory in Portland churning out iPhones? Anyone out there dare to say less than five years? Anybody want to venture a decade?

For the next bit, you will need advanced counting abilities, so it's time to take off your socks too and rope in your toes. Let's start with where the parts come from. The components-supply infrastructure necessary to feed such a factory staggers the mind, with each bit coming from a different part of the world. What's the point in having an assembly plant in the USA if the parts have to come from existing manufacturers overseas?

Of course, the whole matter is ludicrous. It's even more mad when you consider that the USA simply doesn't have the engineering talent and capacity to make this happen. There aren't the bodies available with the skillsets necessary at any one location for this to be viable.

We know this because moves are already afoot to move manufacturing to America. TSMC, the world leader in chip building, is trying to get a new plant running in Phoenix, Arizona. Approximately half of the reported 2,200 employees have been shipped in from Taiwan. They hope to shift the balance to more American employees as these workers gain the necessary skills, but the reality today is that they aren't skilled enough. It would take a generation to overcome this problem.

Tim Cook, CEO of Apple, has made this very clear. He explained that Apple manufactures in China not because it's cheap, but because China has large quantities of highly skilled engineers on tap. One vendor told me that if they needed a thousand engineers who were expert in OLED display manufacturing, and needed them at 3am tomorrow morning, there would be no problem at their plant in China. Try doing that in Phoenix. Or Dunstable or Slough. Excuse me while I pull up the sofa and make popcorn. I'll wait.

In the meantime, just how seriously do you think we take high-end engineering in the UK? We have some of the very best engineering capabilities in the world here, but we can't build at scale. It's almost like we succeed despite our leaders.

Talking of which, let's have a quick run through the current cabinet, and play "spot the engineer". Keir Starmer read law at Leeds. Angela Rayner has a social care NVQ. Rachel Reeves read philosophy, politics and economics at Oxford. Pat McFadden studied politics at Edinburgh. David Lammy read law at London, Yvette Cooper PPE at Oxford, John Healey social and political science at Cambridge. Shabana Mahmood? Law at Oxford. Wes Streeting read history at Cambridge and Lisa Nandy earned her politics degree at Newcastle.

Surely Jonathan Reynolds, the secretary of state for business and trade and president of the Board of Trade would do better? Nope, he read politics and modern history at Manchester. What about Peter Kyle, secretary of state for science, innovation and technology? Yes, mea culpa! He studied engineering at... Oh, sorry, it was geography, international development and environmental studies at Sussex. So easy to get confused.

> "The whole matter is ludicrous. It's even more mad when you consider that the USA simply doesn't have the engineering talent and capacity to make this happen"

Notice something there? Not one of the cabinet members that I have mentioned has any kind of science background – sorry, Peter, geography doesn't count – and they certainly have never worked in an engineering-focused workplace. Are we surprised, then, that our politicians make the choices that they do?

So for sure, bring on a trade war with China. But I don't need a paper chart full of dubious figures to tell you this: we won't win.

Jon Honeyball is a contributing editor to *PC Pro* and has run his own tech consultancy and product test lab since 1989, just in case Donald or Keir want to get in touch. Email jon@jonhoneyball.com

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